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WATER CONSERVANCY IN COMMUNIST CHINA DURING THE LAST DECADE

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[The following are translations and extracts of selected articles from Shui-li Shui-tien Chien-she (Water Conservancy and Hydroelectric Construction), Peiping, No 17 and 18, September 1959.]

TABLE OF CONTENTS

A STUDY OF ACCOMPLISHMENTS IN THE SELECTION OF DAM TYPES FOR HIGH DAM PIVOT PROJECTS AND EXPANSION OF DAM TYPES DURING THE LAST TEN YEARS

[This is a full translation of an article written by Nieh Chen-wei appearing in Shui-li Shui-tien Chien-she, (Water Conservancy and Hydroelectric Construction), No 17, 11 September 1959, pages 7-13.]

Our country has been undergoing rehabilitation for ten years. During these last ten years we have attained a great level of accomplishment in the planning and construction of high dams. We owe such accomplishment to the undeviating guidance of our Party, to the enthusiastic assistance of experts from the U.S.S.R., and to the unrelenting efforts made by the workers who were engaged in irrigation and hydro-electric power work.

Among those dams on which planning has been developed and construction has been gotten underway, there are several vitally important ones. They are the gravity dams on the Hsin-an Chiang and at Liu-chia-hsia; the buttress dams at Pai Shan, Huan-jen and Hsin-feng Chiang; the arch dams at Hsiang-hun-tien and Liu Ch'i Ho; and the earth fill dams at Mao-chi-ts'un and Sung-t'uo). The heights of these dams are over 70 to 80 meters, and some of them are even above 100 meters.

Despite the fact that we haven't much practice in the building of rock fill dams, we have constructed one located at Shih-tzu-t'an. Its height is about 50 meters. Through the stages of planning, construction and operation of various types of dams, the experience we have accumulated are extensive and invaluable.

Inasmuch as we are still planning and will continue to plan dam projects of 70 to 80 meters and even over 100 meters in height, we must study the unsurpassable ways that have been used to select the appropriate types in the past. Such research work is a task of paramount importance.

In celebrating the Tenth Anniversary of the People's Republic of China, this article discusses the basic achievement and practice in the selection of dam types during the last decade. Emphasis is placed on the high dam projects. With regard to the future trend of dam types to be constructed in our country, some suggestions are based on the aspects of their safety and economy, as well as on the types of dams constructed elsewhere in the world.

A. Our Main Accomplishments in the Selection of Dam Types for High Dam Pivot Projects

Technically speaking, the major features in the selection of our dam types may be summarized as follows:

1. The types we have selected are varied: According to incomplete statistics from recent years, the number of dams which are in planning or construction stages is 24. They are all above 75 meters high (including those on which construction has been under way for a fairly long time and those projects which have been only fundamentally approved).

Among these 24 dams, the number of gravity dams is nine, arch dams five, buttress dams six, rock fill one and earth fill three. Some of these have already reached the operating stage. The summarized results on the performance in the operation show that most of the selected types are suitable. Repeated discussions and investigations during the planning or construction period of the others have also verified that generally they were appropriately selected.

Our country covers a great area and includes complicated variations in the conditions provided by the nature. The selection of dam types should be principally based on the physical and natural characteristics of the dam sites. Not only have we fitted our plans to the geographical characteristics of the locality concerned, but also our plans have proceeded in accordance with the climatic conditions of the seasons. Our work during the selection period is, therefore, recognized as of basic value toward the fulfillment of the fundamental principles.

2. There has been a great development in buttress type dams: Many indications show that they have reached the same level as that of the advanced nations. Some gravity counter-fort types constitute a relatively common class among our high dams. Among these, some are completed while others are still under construction. The dams located on the Hsin-feng Chiang, at Huan-jen and on the Che Ch'i all belong to this category. They are over 100 meters high. But the height of another dam, that at Mo-tzu-t'an is only 80 meters.

Besides these dams, a multiple-arch one has been constructed at Mei Shan. Its height of 88.24 meters is unusual even in foreign countries. Through the construction and operation of this multiple-arach type we have gained in our knowledge of its merits as well its drawbacks.

3. The open-slot type of gravity dam has been adopted as a substitute for the regular gravity type: The 105 meter dam on the Hsin-an Chiang, the 110 meter dam at Tan-chiang-k'ou, the 140 meter dam at Liu-chia-hsia and the 165 meter cross-river-channel dam of the Pai Shan hydro-electric power plant are all open-slot gravity dams. So far as the guiding of the discharge and the passing of flood water are concerned, this open-slot type has the same merits as the regular one. As for economy, the concrete used can be reduced by approximately 10 percent in the open-slot type.

4. There has been a special development in projects involving overflow dams: When the dam site is in a narrow canyon or when the stream capacity is very great, there can be many difficulties encountered in the problem of overflow or in the method of arranging a pivot system. The light type of overflow dam or a combination type consisting of an overflow dam with a powerhouse has been adopted to solve such problems. For instance, the 78 meter dam on the Liu-ch'i Ho passes the overflow over its top and carries it away through bucket [canals or channels?] It had been subjected to a flood test for the first time this year. The 67 meter dam at Shang-yu, which has an underground type of powerhouse [enclosed within the dam] has been satisfactorily operated ever since it was completely.

The dams of the power stations located on the Hsin-an Chiang, the Chien Ch'i and in Chao-p'ing are all above 100 meters high. Flood waters flow over the tops of the powerhouses. Their overflow capacity is above 10,000 cubic-meters per second, while that of France's largest dam, Chastang, has an overflow capacity of only 4,000 cubic-meters per second.

The buttress dams in Huan-jen-hsien, on the Hsin-feng Chiang and on the Che Ch'i also permit flood waters to pass over the tops of the dams. Their overflow capacity per unit of width is relatively large. This is especially true of the Huan-jen-hsien dam, which has an overflow capacity per unit of width of 60 cubic-meters per second. Such a record has not thus far been seen in any other country.

Since we have adopted various types of dams, we have accumulated, step by step, varied experience through the planning of projects, the construction work and finally the operation. And, we have trained many teams to do surveying, designing, constructing and scientific study tasks. These experiences and these teams will contribute to future progress in the building of dams.

B. Basic Experiences in the Selection Work of Our Dam Types

Through several years of practice, our country has gained very much experience in selecting dam types.

1. Basic information is well prepared. Reliable foundations underlie our selection of dam types: This is really a principal experience of great importance. Such experience, however, was only obtained by learning through errors. For instance, in one location, only by basing our decision on superficial topographic characteristics and a few abstract assumptions of its superiority over others did we decide to use it as a site for an arch dam.

In fact, the geological data affecting the dam foundation and the base areas for the abutments on both ends were not clearly explored. When the construction was started we found out the geological conditions were un-

satisfactory. Hence, we had to restudy the situation and change the type of dam. As a result, the project as well as the construction work was compelled to come to a passive halt.

Another instance occurred when some designers recommended a project of erecting a rock fill dam with slab cores. But the quality and the quantity of the slabs were not thoroughly investigated. Some people elected to make use of materials available near the site. But they were prompted too much by their own wishful thinking about the specified materials, and not by an adequate analysis of the possible supplies. As a result, these dams were not as strong as we planned and a serious situation subsequently arose during the flood season.

In some cases, it was apparent that suitable materials were available near the locality concerned but careless explorers reported that they were not. Consequently, the selection of the dam type was affected when comparison between the different projects was made.

Therefore, all studies and all comparisons can be made accurate only if the basic information on which they are based is accurate and reliable.

2. Natural data at the dam sites are fully considered: The advantage of a certain type of dam can be maximized and its disadvantage can be minimized if the selection of the dam type is based on the geologic, topographic, hydrologic and climatic conditions of the dam site. For instance, the advantage of an arch dam can be fully developed in respect of its safety and stability, only if its width is in an appropriate proportion to its height and its geological conditions are sufficiently favorable.

Again, if the dam location is in a narrow gorge and the capacity of the stream is tremendous, the weakness of the light type of dam or the dam built of local materials will be immediately brought to light. The crucial point is connected with guiding the stream and discharging flood waters.

Conditions of extreme cold adversly affect dams, particularly the thin buttress type.

Opinions are often at great variance on these problems during the study of a basic project. When the strength and size of a dam foundation comes up for discussion, it might be discussed according to the order of the types: arch, buttress, gravity, rock-fill and earth-fill; and the demands for these respective types can be lessened little by little. In this way, the different views can be made more unanimous. However, disagreement always arises when the real value of a given site comes up for appraisal.

Therefore, in the study of dam problems, a correct conclusion can be reached only through a thoroughful comparative study. Not only should the dam site be considered during selection of the type of dam, but also consideration should be given to the type before the selection is made. A more rational project can thus be obtained.

3. The dam types are studied, starting with the conditions needed for the entire pivot arrangement: Because the pivot arrangement is closely related to the topography, geology and hydrology of the locality concerned, these several items should be considered altogether during the study of a dam type. For instance, if the type selected would not allow the overflow of the stream to pass through the body of the dam, the solution of the problem of how to handle the overflow would be quite difficult.

However, if there is a suitable gap in the vicinity of the dam site, which could be used as a passage to discharge flood waters, then the solution would be easier. Otherwise, the ditches and tunnels as well as the conduits underneath the dam must be considered. The extra materials (steel, cement and explosives)required for construction would add to the cost. Probably, the costs of the added items could not be off set by the savings realized on the dam itself.

If a dam built of locally obtained material is decided upon, the arrangement for installation of it power unit will increase the investment and increase the loss of the water-head, no matter if the conduits are installed underneath the dam or a separate tunnel is opened.

The problem of navigation also sometimes affects the selection of the type of dam.

4. The conditions required for the construction of various types of dams must be thoroughly studied so that the construction of any selected type can be realized. In making studies to elect a certain type of dam, the conditions which determine the feasibility of the project should be fully considered. The manner of guiding the streamflow, the rapidity of the construction process, the arrangement of the area slated for construction work, the materials used, the labor required, the way of supplying the equipment necessary for construction and the water level during construction are all main features. They are also main factors which determine the realization of the requirements stipulated in the planning of a certain type of the dam. These factors should not be overlooked.

5. Under favorable conditions, preference is given to dams built with locally available materials. Based upon a sound technical basis, attention should be paid to the economy of using either steel, cement or other materials. This should be a permanent rule for those who are engaged in irrigation and hydro-electric power work to abide by.

In view of the fact, that the nation-wide basic reconstruction at present is so swiftly expanding that the materials for construction purposes are not produced as rapidly enough to meet the demand, it is of great significance that dams be built with local resources. In addition, some other important reasons for the adoption of building dams with locally available material are as follows:

(a) Colossal concrete dams need many hundred-thousand tons of cement shipped from areas removed from the dam locations. This adds a serious burden to transportation facilities. The present construction work on the trunk lines of new railways is so overwhelming that it is impracticable to build a special road for the exclusive use of hydro-electric stations. Transportation of materials by trucks does not always satisfactorily meet the construction needs.

(b) In our vast country, many regions possess some good locations for building hydro-electric plants, but good materials which can be used as aggregates with the concrete are not available because of the special characteristics of the rocks in those areas. (For instance, some

places in southwest China have only limestone in abundance). But, the difficulty in obtaining the necessary construction materials can be overcome only by constructing dams with locally available material.

(c) In some places, the conditions of the hydrologic resources are favorable but the geology of the foundation is not satisfactory enough to erect concrete dams.

(d) Although we have accumulated certain experiences in the planning and building of high concrete dams, we haven't enough practice in the design and construction of high dams built of locally available materials (especially rock fill dams). For the sake of future development, we must try to gain experience in building dams of this sort.

For the reasons mentioned above and so long as the conditions are favorable, it will be preferably if we construct dams from locally available materials even if the costs are a little higher.

6. New types of dams are progressively and carefully studied and adopted: We have displayed great performance in this respect. The dam at Shang-yu-hsien which includes a powerhouse and the dam at Hsin-an-chiang which allows overflow caused by flooding to spill over the top are, in a sense, new types. We use four words: numerous, rapid, good and economical as principles to guide the building of our irrigation and hydro-electric plants. We should collect all relavent facts from all the dam locations as references in order to proceed with our study and to create new types of dams.

The above-mentioned points merely represent my personal superficial knowledge about the selection of our dam types. Naturally, my knowledge is far from sufficient to encompass the wealth of the experiences our country has acquired. However, the practices have given corroborative evidence that the several points of experience noted underlie great guidance for the future selection of dam types.

C. Safety and Economy of Various Dam Types

During the last two years, a variety of opinions have entered into the discussion about the trend of future

development of dam types to be utilized in our country. This question represents a fundamental understanding which will greatly influence our ability of deciding on the specific types of dams to be constructed. I, therefore, have proceeded to study the trend of future development. This study is based on my personal views and starts with a discussion of the advantages as well as the disadvantages of the various types of dams with respect to their safety and economy.

1. The matter of economy: The matter of economy is reflected first by the cost of erecting a dam. The unit costs of construction which chiefly govern the costs of erecting a dam vary with the level of the industrial development of the different countries. In the United States, for instance, mechanized equipment is utilized in the construction work and therefore, they like to erect large-sized dams in that country. The unit cost of construction can be lowered despite the fact that the size of the dam is increased. In terms of total cost, it is still economical.

The Kuo-hsing-neng Dam in Switzerland was originally planned to be a concrete gravity dam. But after large American machinery for construction use were imported by Switzerland, the cost of constructing an earth filled dam was apparently reduced.

As a result, an earth dam was then substituted for the concrete one. The situation in some countries in western Europe, like France, is quite different. The unit cost of construction of an arch concrete dam in France is 15 percent higher than that of a gravity one. But the volume of the concrete part of the dam can be reduced by about 30 to 60 percent. Therefore, the cost of building an arch dam is generally 40 to 70 percent of that needed for building a gravity dam of the same size.

So far as our country is concerned, there is no complete and reliable information about such unit costs of construction. Recently, while we adopted approved estimates and new unit costs of construction in some high dam projects, they will have to be revised during the process of construction.

The cost of the dam proper alone does not fully represent the total cost. The influence of a dam type on the pivot arrangement it requires should be taken into consideration. A comparison should be made between the total cost of the entire pivot and the conditions required during its operation.

The method of discharging flood waters and the arrangement of a power-house structure are always main factors which determine the cost of a certain type of dam. These factors depend greatly upon the topographic and geologic conditions. If, in the vincinity of the dam, a suitable place can be used to erect a water outlet structure, the problem of disposing of flood waters would not present an obstacle to constructing light type of dams or dams built from locally available material.

In the diversion embankment type of a power station, the location of the powerhouse is always unfavorable to the kind of dam built of materials obtained from local sources. But it doesn't affect the dam unfavorably if the station is of a multiple-purpose type.

The speed with which various dam types can be built is another thing which should be considered in discussing costs; for the more quickly a dam can be built the sooner it will satisfy the economical demands of the people. Great benefits in terms of economy can be derived from speedy construction. Some countries have paid no heed to this matter. For example, Switzerland took nine years to build Mo-wa-sang arch dam, and six years to build Kuo-hsing-neng earth dam. The principles used for the construction of the dams in our country are: numerous, rapid, good and economical.

Economies in construction should be established upon a practicable basis. Besides technical conditions the materials used for construction, such as steel, cement, timber and dynamite, the preparatory arrangements for construction and the labor resources should be fully considered.

In summary, in weighing the economy of building a certain type of dam, not only should the dam itself be considered, but it is also necessary to consider the structures associated with the dam. That is, not only should

the cost of erecting a dam be considered; it is also necessary to consider the time required to build the dam together with its associated structures. In addition, it is also necessary to consider the feasibility of a particular type of dam from all points, such as techniques, materials, equipment and labor.

Therefore, it is impossible and not advisable to say with certainty which type of the dam is most economical. The only way of determining the most economical dam type is to collect data on the natural conditions of the dam site; figure out the practicability of supplying construction materials, equipment for construction use and labor; then all the factors must be considered together to determine the manner of arranging the pivot; and finally a thorough comparative study must be made.

2. Matter of safety: By all odds, the most important matter to be discussed is the safety of the dams, especially the high ones. The failure of a high dam will mean a great catastrophe for the cities and villages situated downstream from it. Safety and economy are to be matched, but economy cannot take precedence over safety.

Consideration of safety, however, should not be limitless. It must be defined by a certain standard. This standard is determined by the amount of stimulus the dam will have on the political economy. [i.e. if the dam would be important to the economy expense should not be spared.] (Two considerations are taken into account.

One is the purpose of building a specific dam with regard to the economic welfare of all people in the country; and the other is the effect of the catastrophe which would be felt by the economy of the country as a whole in the event of dam failure.) These two considerations determine the cost, which is considered in terms of the stimulus the dam will provide for the economy. Such costs are concretely reflected by the classifications and gradings of the hydro-electric structures, and by the standards of other projects too.

In studying the safety of a dam, there is always some one who brings up the matter of overload for discussion. Some even contended that some types of dam are strong

enough to withstand an air raid while others were not. As matter of fact, this is of no real significance in discussing safety from a purely technical point of view.

The problem of flood also comes up for discussion. Usually in terms of how big will a possible flood be? Or, how big of an unexpected flood must be withstood in order that a dam can be regarded as safe? If these questions are not answered, it is also meaningless to say which dam has enough strength to resist a probable flood.

Therefore, in discussing the safety of a dam, it should not be discussed beyond the stipulated conditions (those stipulated in the project standards). For instance, if according to the project standard, a first grade dam should be capable of resisting a flood of 0.01 percent intensity,any dam which can fulfill this requirement has equal strength against the flood, no matter what type it is.

According to the history of dam construction, failures have been recorded for almost every type of dam. This is why, without the support of actual experiences, talk of which type is more safe and which is less is empty and groundless.

The safety of a dam is determined by: (1) Whether the project is formulated in accordance with the real situation; and (2) Whether the quality and quantity of the materials for building the dam are prepared in accordance with the demands of the project.

In fine, because different types of dams have different histories of developments and different levels of studying their related sciences, they have, therefore, different levels of their projects. The level of a project is reflected principally by the practicability of the assumption on which the project is based, of the theory used and of the way adopted for constructing the dam.

In order to make a further study of this matter, the following discusses separately some principal types of the dams:

(1) Gravity dams--Because the gravity dam is a substantial block and the calculation needed in its design is

simpler than that of other types it seems to us that the problems it presents are fewer. But a detailed analysis shows otherwise. For instance, the current method of calculating the stability against slide considers friction only. But the question of how to make a rational choice of the coefficient of friction is not yet answered. Although it can be chosen through laboratory tests, the results vary greatly with the different ways of treating the contact surfaces. Therefore, the coefficient of friction is actually adopted, to some extent, at random.

In addition, percolation has a great influence on calculating the stability against slide. But in the design of a gravity dam, it is not easy to indicate an accurate percolation factor beforehead. Although some information obtained during the construction survey may be used to determine it, it is difficult to conclude that the extenting of percolation estimated from such data would coincide with the actual condition in the completed dam.

How percolation affects the stress on the dam body is also unknown. As a general rule, it is regarded as an internal or external force, calculated by using some formulae from the General Theory of Elasticity or Strength of Materials. A few paradoxes, nevertheless, are involved in this way of calculating the percolation.

During the construction of a high dam, some materials are cut into blocks, some are mixed with water and some are crushed into pieces. When the dam is put up many joints are formed: vertical, diagonal and zigzag. How do these cut, wetted and crushed materials as well as the vertical, diagonal and zigzag joints affect the distribution of stress? How do these different forms of material and different forms of joints affect the entire body of the dam which is supposed to be a monolith? At the present level of theory, there is still no way to completely solve thes problems.

(2) Arch dams--the arch type of dam involves complicated calculations. It is questionable whether such calculations really reflect the stress conditions in the body of the dam. We must also ask how useful is the study made in a laboratory? It is worthwhile to further discuss these questions. Deformation of the abutments of arch dams has a great effect on the body of a dam.

However, there is no reliable method to determine the extent of such deformation with any accuracy. The question of whether the overflow of the stream over the top of an arch dam might cause shock to the dam is also debatable. With regard to the different forms of joints, etc., the questions which apply to the arch type of dam are similar to those for the gravity ones.

(3) Buttress dams--The detrimental effects of percolation on buttress dams are less than those on the gravity type. In this respect, the former are superior to the latter. However, with regard to the stability against slide as well as the conditions resulting from the different kinds of joints, the questions are same for the buttress type as for the gravity dams. In both cases there are no clear answers.

In addition, it is questionalbe as to how great the strength of buttress dams against earthquake shock might be. And, would the overflow of the stream shock a buttress dam? And under a high water head, how stable would a buttress dam be in terms of vertical deflection? These are all moot questions, since our practical experience has not answered these questions nor has offer theoretical studies given any perfect solution.

Finally, we must hypotesize what would be the strength of a thin buttress dam to resist the percolation if some cracks developed. Many engineers are trying to solve this problem.

(4) Earth fill dams--Although there has been a great advancement in geophysics during recent years, the way of designing an earth fill dam is, in many respects, based on a particular theory towhich a perfect solution is difficult to arrive at. For instance, there are many laboratory to determine the shear resistance of earth. But which method should be chosen to meet practical requirements is a big question. In addition, the pore pressure and liquefaction of sand necessitates further study.

(5) Rock fill dams--If one thinks the theory of elasticity can be regarded as a main weapon in the analytic study of concrete dams and geophysics as the main weapon in the comparative study of earth fill dams, there is no such specific weapon to be used in the study of rock fill ones.

Although we have often used geophysics or the theory of elasticity and plasticity in working out the designs of rock fill dams, the theoretical results more or less deviated from the practical conditions. In a addition, many other problems are, so far, not solved. Rock settlement is one of them, as there is no precise way to predetermine the extent to which rocks will settle.

Summarizing all the facts stated above, it is evident that in the case of all these types of dams there are a great many unsolved problems. Because their problems are not solved, no conclusion can, therefore, be reached. Because there is no way to predetermine the safety of these dams, therefore, we can not guarantee how much safety can be required.

Despite the fact that the theoretical methods (including many traditional methods of calculation) can not give us exact answers for practical use, they do provide us with many principal rules and formulas concerning a dam. Having these rules and formulas at hand we can do something to cope with any probable situation and to preserve the safety.

Moreover, the experience we have obtained from the operation of those dams already in service can be helpful to us in eliminating the weak points in the various types of dams.

Between the assumptions on which the designs were based as well as the methods by which the designs were calculated on the one side, and the practical conditions on the other, there has existed a gap. In order to close such a gap so as to insure that the structure is free from danger, we generally established a certain safety factory and set forth some [minimum] technical demands. For example, in the formula for calculating the stability against slide of a concrete gravity dam built on a rock formation, cohesion was not taken into account. But even without that the safety factor was approximately 1.0, which is what is generally required for stability against slide on such a dam. The unconsidered factor of cohesion, which is an inherent element, therefore, added to the safety.

In earth fill dams, because there were more unknown elements involved in estimating the stability of their

sloping faces and less latent elements which would be beneficial to the structure, the safety factor for the stability of the slopes is from 1.3 to 1.5.

With regard to the allowable stresses in gravity dams, because the difference between the effects of percolation on the stresses of the dam before and after the crack developing at its upstream face was not clearly understood, no appreciable tension stresses were permitted at its upstream face. At the same time, a good drainage system was provided inside the dam to relieve the uplift pressure.

In the arch type dams, the increase adverse effects of percolation resulting from cracking is not serious enough to impair the dam safety. A certain amount of appreciable tension stresses was, therefore, allowed to be present on its upstream face.

The safety factors, which differ with the types of dams, were determined by thoroughly studying a specific type and by the estimated extent of detrimental effects caused by a certain element on that specific type. This is why a dam which has a greater safety factor is not necessarily safer than a dam which has a smaller safety factor.

Generally speaking, the elements involved in determining the safety of different types of dams are different. It is the stability against slide which determines the safety of gravity and buttress type dams; it is allowable stresses which determines the safety of buttress and arch type dams; and it is the slope stability and reliability to resist percolation which determine the safety of earth-fill and rock fill dams.

In a nutshell, so far as the requirements for stability, strength and resistance against percolation are concerned, each of these dam types has advantages as well as disadvantages. But inasmuch as the safety is conditional and these requirements are the established conditions under which safety is insured, the current level of scientific techniques can insure that all these requirements are met, whatever the type may be. However, these requirements should be taken into further consideration in view of the true standards set for construction work.

The quality and quantity of materials available for construction purposes constitutes an element which most directly determines the safety of a large dam. Whether the construction material satisfies the design demands is an important condition which often affects the selection of dam types. For instance, a high arch dam in which the estimated stress will always reach 80 to 90 kilograms per square centimeter needs concrete of above #300 standard. At present, in some regions of our country, because the concrete produced fell short of this standard, this demand could not be satisfied and consequently the arch dam project had to be shelved.

In extremely cold regions the demand for a freeze resistant standard in buttress type dams and in general locations the demand for an anti-percolation standard in the same type are both relatively stringent. If these standards can not be insured in certain qualities and quantities of the construction materials, the durability of the dams will be affected.

It has happened in some places that the materials used were not sieved well and that the aggregate material were so unsuitably selected that they could not meet the percolation-resisting and freeze resistant standards. As a result, the buttress dams were threatened with ruin.

In addition, the dissipation of heat in concrete dams; the control of porosity in rock fill dams; and control of the quantity of water in percolation-resisting earth dams and the control of gravel weight in masonry dams will influence the selection of dam projects if, owing to inadequate equipment or some other reasons, the quality and quantity of materials can not be guaranteed during construction.

The progress and procedure of construction bear relation to the safety of various types of dams during particular stages of construction. In one instance, the progress of building a rock fill dam was too optimistically scheduled to be 4,000 cubic meters per day.

Actually, only 1,000 cubic meters of dam could be erected daily. During the season of high water, torrents came raging down the river. The dam was not high enough to hold back the water, and the water flowed over the top.

Not only was most of the erected part of the dam wrecked, but in addition disaster was spread over the lower valley.

Similar lessons were taught during the building of earth fill dams. It was these lessons such as these which have alerted us to the fact that in the design of dams built from locally available materials, the way of guiding the stream and the speed at which construction proceeds must be arranged with special care.

Under general circumstances, this problem can be solved. But if the capacity of the guided stream is tremendous and as a result the embankment put up must be very high so that everything will be under control during the first phase of construction, we need a sufficient amount of mechanized equipment to cope with the problem. For instance, according to the study of some rock fill dam projects in our country, 10,000 to 20,000 cubic meters should be put up every day during the first phase of construction.

We may take similar rock fill dam at Yu-mu in Japan as an example. The daily quantity of material deposited during the first phase was almost same as on our dam. The main mechanized equipment used was:

25 power shovels (including four 4.5 cubic-meter-power shovels) to do the quarrying and excavating work

96 heavy trucks (including forty 22 ton-self-dumping trucks) for hauling rock

6 twenty to twenty-five ton cranes

2 fifty-ton pneumatic-tired rollers

4 twenty-ton sheepfoot rollers

Notwithstanding the fact that the damage caused by flood waters flowing over the top of a concrete dam is small, the torrents which rage over the tops of buttress or open-slot gravity dams during construction of them might destroy the foundations of the dam because work is incompleted on the downstream side.

The procedure and progress of construction determines the distribution of stress on a dam. If proper attention is not paid to these factors a dam might be brought into jeopardy. For instance, if the construction work must be done with so much haste that the closing sections of arch, gravity or buttress type dams are poured before the concrete is cooled to the setting temperature, extra stress might arise from later contraction of the concrete blocks. And, the fact that the concrete blocks are put up individually might also cause a change in stress beyond that estimated in the original design.

If all these factors mentioned above are not adequately estimated beforehand, they might have detrimental effects on the soundness of a dam. But if they are all involved in the estimation, the estimation would result in an increase of the quantity of concrete required which would influence the cost to some extent.

In addition to the above factors of design and construction, consideration should be given to the facilities for maintenence and the practicability of repair in case of damage after completion of a dam. In these respects, thin buttress type dams (like multiple arch and flat-slab types) are most unfavorable.

This is because in the vent of cracking or other damage concrete can not be poured from their tops or walkways. And, it would be impossible to empty a large reservoir. (In our country, the capacities of reservoirs are from several thousand million to several ten thousand million cubic meters. Therefore, special care should be taken in constructing a thin buttress type dam in a situation which will involve a large reservior

In summary, each type of dams has particular elements, same favorable and some unfavorable, which affect its safeness. The cost of a dam is also affected by many factors. But, safety and economy can not be dealt with in the same manner. The two must be considered in accordance with the circumstances which exist at the time.

D. Trends in the Selection of Dam Types in Foreign Countries

In order to further explain the trend of development in dam types, it will be well to note the trend in the selection of types in foreign countries.

According to incomplete statistics, the capitalist countries possess 336 dams which are above 75 meters in height. This number includes those which have been completed, those which are under construction and those which are still in the planning stage. The following table classifies them by type [and height]:

Dam types	Total		Completed or designed after 1950		Completed or designed after 1950 percent of total	
	75-100m	100m	75-100m	100m	75-100 m	100 m
Gravity	97	66	67	47	60%	71%
Arch	52	48	23	36	44	75
Buttress	10	3	5	2	50	67
Earth fill	24	9	16	8	67	89
Rock fill	24	14	15	11	63	79

From the above table we can see that the number of gravity dams is the greatest, and that arch dams are second. The other three are, in order, the rock fill, earth fill and buttress types. If we use the year 1950 as a starting date, the high dams which were completed or which were being constructed after that year were still basically conforming to such a trend, so far as the absolute figures are concerned.

However, relatively speaking, the percentage of dams over 100 meters built of locally available material has been increased. But this doesn't mean that the trend in every country has developed in the same way. The dam construction in some principal capitalist countries can be observed as follows:

(1) United States---In general, the high dams in the United States follow the same pattern as those in the capitalist countries as a whole. But since 1944, while there has been a noteworthy increase in earth fill and rock fill dams, not a single high buttress one has been erected. The high dams of the United States are constituted as shown in the following table:

Dam Types	Total		Number of dam after 1950		Number of dams after 1950, % of total	
	75-100m	100m	75-100m	100m	75-100 m	100 m
Gravity	22	14	11	6	50%	43%
Arch	11	10	2	3	18	30
Buttress	3	1	0	0	0	0
Earth fill	15	5	9	5	60	100
Rock fill	12	6	5	4	42	67

(2) Japan---The number of gravity dams in Japan is overwhelming. But higher arch, rock fill and buttress types have also been built during recent years. The types in that country are constituted as follows:

Dam types	75-100 m	Above 100 m	Remarks
Gravity	38	19	A minority of these has been completed; the majority are in the designing or construction stage.
Arch	2	3	
Buttress	0	1	
Earth fill	1	0	
Rock fill	0	2	

(3) Switzerland---Since 1951, Switzerland has built seven dams which are above 100 meters. Among them, four are arch type. They are Mo-wa-sang, Chiang-chi-erh, Chiang-fu-sui-la and Mo-a-l. Two dams, Ta-ti-k'o-sun and A-li-nieh are gravity type. The Mo-hsing-neng dam is of the earth fill type.

(4) France---During the last ten years, France has built 32 concrete dams (including those which are less than 75 meters in height). Of them, 26 are arch types, four are gravity and two are buttress types. Although there are not many built of local materials the earth fill Sa-erh-lung-sang dam has a height of 122 meters.

(5) Italy---Only one gravity type dam, the Sa-erh-to Dam which has completed in 1939, is above 100 meters in height. Among three other 75-100 meter high gravity dams, two of them were built after 1950. Italy has more arch dams than other types. Of them, 13 are over 100 meters high and 10 of those 13 were built after 1950. In addition, Italy has developed arch dams with double curvature.

There has also been a great development in buttress type dams (gravity-counterfort dams) in Italy. Three dams of the gravity-counterfort type have been constructed during recent years. One of them has a height of over 100 meters, and two are 75 to 100 meters high.

With regard to the socialist countries, Soviet Russia has erected many high dams in Siberia. Among them, Pu-ha-t'a-erh-ming-ch'i-chi, the Shu-erh-pin-ch'i-chi, Pu-la-tz'u-k'o, K'o-la-ki-jo-ya-ch'i-k'o, Sa-yin-ch'i-k'o, and Chiang-ya are gravity dams. Ta-lei-fu, Ta-li-a-erh and Ch'a-erh-wa-k'o are earth fill dams. The principal dams in Russia are of the gravity type.

The general trends in the designs of high dams in many countries can be seen from the above summarized figures. In order to further explain these trends, the following discusses again the various types of dams.

(a) Thus far, the gravity type is still the most popular. Despite the fact that gravity dams need tremendous amounts of concrete and have a drawback in that their strength cannot be fully exploited, they are superior to others in the guiding of streams, handling flood overflow

and arranging the pivot systems. This is why they are popular. But besides these, some other reasons support their adoption by many countries. For instance, because the United States can use heavy machinery to build gravity dams the labor and cost can be reduced. It is this reason which prompts that county to build gravity dams. Another example is Japan. Because that country is subject to earthquakes, the Japanese have built many gravity dams because that type is recognized to have a strong resistance against shock.

In Russia, most of the dams are located in Siberia where such unfavorable conditions as extreme cold and great innundation have prevented the Russians from maintaining light types or erecting dams built of locally available material. They must of necessity use gravity dams. Use of gravity dams of the open-slot type has been greatly developed in our country, in Soviet Russia and in Switzerland.

(b) Arch dams are second to gravity ones in number. Owing to some natural conditions France, Italy and other European countries have focused special attention upon the construction of arch dams. This is because their dam sites were in narrow gorges where flooding is not great and the problems of guiding the streams and discharging the floods is simpler. The building of arch dams is, therefore, advantageous for those countries.

In addition, the savings in the quantity of concrete used, the level of the technique of skilled labor and the time for constructing the arch type dam permitted using a better quality concrete. This is the reason why more countries in Europe adopted arch dams.

(c) During recent years, there has been a great development of buttress type high dams, chiefly gravity-counterfort ones. Most construction of this type was done in Italy. Notwithstanding this development, the gravity-counterfort dams presently do not acctount for many in the overall figures. However, the combined great merits of the gravity and buttress types will result in great development of them in the future.

In the early years of dam construction in the United States, some of the multiple arch dams built were relatively

high. But since 1944, Americans have almost ceased building such types of dams. There are several reasons for this. Among them are that the multiple arch type needs vast quantities of steel reinforcement, and the method of construction is complicated. In addition, in the event of cracking leakage would be serious and repair and replacement are not easy. Moreover, they are generally more expensive than gravity-counterfort types.

However, multiple arch dam with spread footing is a new development in dams of low height. Basically, this development can eliminate the general defects which are inherent in the [standard] multiple arch types. This merit is sufficient to warrant its further development.

(d) High dams built of locally available material have had an outstanding development during recent years, particularly in the United States. About 50 percent of the dams built in that country after 1950 and were over 100 meters high were built of locally available materials.

One of the reasons for this development is that confidence in such dams has been strengthened by advanced theories of design. The other reason is the great progress which has been made in construction machinery which not only makes possible the erection of high dams but also greatly reduces the unit cost. Besides, good sites for erecting dams are diminishing. Therefore, dams built from local material were chosen in preference to concrete ones.

From the above facts it can be observed that:

(1) Despite the fact that various countries at certain times, have designed and constructed certain types of dams more often than other types because of existing conditions, they did not rule out the construction of the other types altogether. And, as can be seen from the general trends of dam development in the world, although the rate of development in different countries varies, no country has reached such a stage that a departure from the conventional types built is justified.

(2) In considering the types which make-up all the dams in our country, it is noted that they are relatively varied. To compare these various types with those in the

other countries which have similarly complex natural conditions, one can see that each type is in normal proportion to the rest.

(3) Many types of dams have been further improved in the wake of the advancement of both theories and practices in dam construction. As example, regular gravity type dams are losing their place to the open-slot gravity type; gravity-counterfort dams are taking the lead in the buttress groups; a new type of multiple arch with spread footings has appeared; the arch type with double curvature is being greatly developed; and the rock fill type with masonry cores has become popular.

Few of the rock fill type dams with rigid cores and few of the thin buttress dams, such as those with a multiple arch, were being built in recent years. The tendency has been to drop them from that group type.

Conclusion

The following conclusions stem from the above discussion. The selection of a dam type must be based upon the topographical and geological conditions which are provided by the nature; the practicability of supplying materials and equipment; and upon the level of development of technical skills. If a person talks about dam types without concrete information on these conditions at hand, and jumps to a conclusion that a particular type is the correct one and that is incorrect, he cannot have an adequate understanding of the overall picture of dam construction.

It has been the case with all countries that in different eras of history and with different existing conditions the characteristic points of the dams which were developed have differed. Our country is, now, living in an era of a big leap forward toward the establishment of socialism. The advancement of all branches of the economy is so swift that the supply of such materials as steel, cement, timber, etc., cannot fully meet the requirements of reconstruction.

In order to obviate such a paradoxical situation and to push a bigger leap forward in the irrigation and hydro-

electric field, the Department of Hydro-electric Power as well as the Bureau of Irrigation and Hydro-electric Power Reconstruction have suggested that the adoption of dams the local-material built of locally available materials are to receive preference. This proposal is quite right and is generally recognized to be in conformity with the present real situation. Special attention should be focused upon the such dams in the selection of dam types.

However, the selection of such dams does not mean the exclusion of all other types. Therefore, it behooves us to continue to study and to improve those other types. We had best make an effort to attain a greater achievement in the development of all types of dams.

DOMESTIC (CEMENT) PLASTICIZERS AND THEIR EFFICACY

[This is a translation of an article submitted by the Water Conservation Research Laboratory of the Anhwei Water Conservancy and Electric Power Institute. The article in Shui-li Shui-tien Chien-she, No 17, 11 September 1959, pages 14-20.]

(I) Prologue

When cement is mixed with water, a cement paste is formed and then hardens. According to the experiment made by Dr. Tokujiro Yoshida of Japan, if the paste hardens at the age of three days, the water required is approximately 10.8 percent by weight of the cement; if it hardens at the age of seven days, the water required is approximately 13.5 percent; if it hardens at the age of twenty-eight days, the water required is approximately 17.9 percent. According to the study made by Professor Shinohara of Kyushu University of Japan, the weight of water needed for a complete hydration of the cement is only 32 to 37 percent of that of the cement itself.

However, this 32 to 37 percent, which is referred to as a water-cement ratio, is not high enough to make the cement fluidic, plastic and workable. The water-cement ratio of 45 to 75 percent is, therefore, usually adopted when concrete is used as a building material. Because more water is added than can combine with the cement, there is always about 50 percent of water which is free in the concrete. Such free water evaporates when the concrete dries, leaving voids which lessen the strength and impair the durability of the concrete.

In order to reduce the amount of such free water so as to improve the properties of the concrete many attempts have been made. The adoption of a relatively low water-cement ratio, the careful selection of appropriate gradings of aggregates, the use of machinery for pouring and crushing, the use of stiff concrete and the method of drying the concrete in vacuo all contribute to the reduction of excess

water. During recent years some admixtures have been introduced. These admixtures will serve as a new method for the improvement of the properties of the concrete.

The admixture which was first applied to concrete in our country was gaseous. Afterwards, they were the waste liquors of paper making from the paper factories at Shih-yen, Ying-k'ou, Chin-chou, Tientsin, Kuang-chou and Shanghai. The use of these admixtures, which are now referred to as plasticizers, is widespread, but their production is so limited that it is impossible to meet the needs of recent reconstruction, which has undergone tremendous development.

This article discusses the simple methods of manufacturing the new plasticizers. The materials used for manufacturing them are sunflowers, pine leaves, and rice stalks, which can be found everywhere. The methods and explanations are set forth in such a manner that they will provide a ready reference for water conservation engineers.

(II) Specimens

(1) Cement---No 400 silicate cement manufactured by the Lung-t'an cement manufactory in Kiangsu was used as a specimen. Its chemical composition and physical properties are shown in the table 1 and table 2.

Table 1 Essential Chemical Composition of the cement

Loss on Ignition Percent	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %
1.19	28.10	7.52	4.88	54.85
	MgO %	SO_3 %	S %	
	0.83	1.36	0.56	

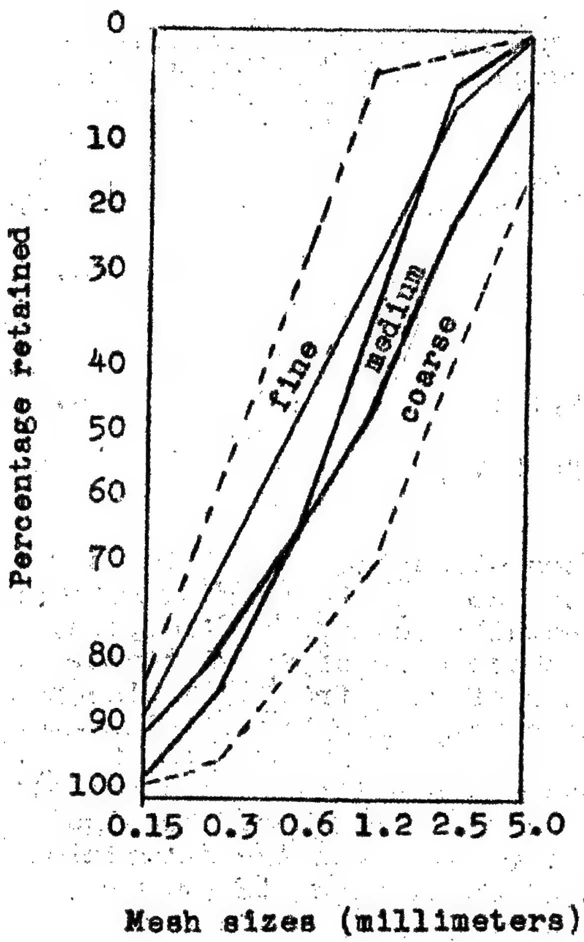
Table 2. Essential Physical Properties of the Cement

Standard No of the Cement			
Tensil Strength Kilograms Per cm^2		Compressive Strength Kilograms per cm^2	
7 days	28 days	7 days	28 days
18.7	24.0	241	418

Stability		Periods of Setting			Specific
Steamed	Boiled	Percent Water added	Initial set	Final set	gravity
Desirable		24.7	$3^h\ 45^m$	$5^h\ 58^m$	3.09

(2) Fine aggregates---Sands from Pine-chuang were used. Their physical properties are listed in the Table 3 and their sieve analysis is shown in Figure 1.

Figure 1. Sieve-analysis curves for the aggregates.



(3) Coarse aggregates--Gravels of granites from Huai-yuan were used. The diameters of small gravels ranged from 0.5 to 2.5 centimeters and medium gravels measured from 2.5 to 5.0 centimeters. In the mixed aggregates, the amounts of the small the medium gravels were in the ration of two to three.

The physical properties of the coarse aggregates are shown in the table 4.

Table 4. Essential Physical Properties of Coarse Aggregates

Weight-Volume: (Kilograms/cubic meter)	1426
Specific Gravity:	2.63
Porosity (%):	45.8
Water Rententivity:	0.43
Anti-Freezing Property:	M50

(4) Plasticizers--Domestic plasticizers were used. They were classified as pine-leaf product, sunflower product, and rice-stalk product. To compare these plasticizers with those made of waste liquor of paper making, waste liquor of reed from the Chin-chou paper manufacture was also used as a specimen in the test.

The stems of reeds are boiled with a sulphite and all the fibrous substances are removed, the liquid left is the waste liquor of reed. When the materials, such as sunflowers, stems of corn, rice stalks, or wood, which contain albumen and carbohydrates, are cooked with a considerable quantity of NaOH, the vegetable ingredients of those materials react with the alkali to form a vegetable-alkali solution.

When all the fibrous substances are removed, the vegetable-alkali solution is a domestic plasticizer. The detailed process of manufacturing the domestic plasticizers is as follows:

a. Cut and grind the pine leaves or the stems of the sunflowers or corn. Measure the amount of water they contain.

b. Prepare a 5 percent solution of NaOH (50 grams of NaOH per liter of water.

c. Pour two liters of the above prepared solution of NaOH into a boiler and heat it. Add one kilogram (dry measure) of those ground materials, little by little, into the boiler.

d. Boil it and maintain the boiling point for four to five hours. Stir constantly. Don't let any burnt organic matter stick to the bottom of the boiler.

e. Remove the fire, let the liquid cool off, filter off the residue, and finally neutralize the liquid with hydrochloric acid. (Test it with litmus paper)

The essential physical properties of the plasticizers are listed in the table (5).

Items	Waste Liquor of Reed	Sunflower Product	Pine-Leaf Product	Rice-Stalk Product
Appearance	Br Liq	Br Liq	Br Liq	Br Liq
Sp Gr	1.15	1.06	1.03	1.02
Solid Matter gm/c c	0.324	0.111	0.06	0.036
CaO, mg/lit	11263.53	247.65	200.08	36.38
MgO, mg/lit	27061.60	1278.84	777.93	298.41
SO3, mg/lit	14943.91	621.24	220.12	84.79
S, mg/lit	10832.97	508.97	309.61	118.76

Table 5. Essential Physical Properties of Plasticizers

(III) Prerequisites of Experiments

1. The maximum diameter of the aggregates for the concrete was five centimeters.

2. The slump of the concrete was six to eight centimeters.

3. The amount of sand in the concrete was 32 percent.

4. The concrete was disturbed with machinery, except the concrete molds which were used for the antifreezing test, all were stamped with machinery.

5. The size of the specimen for the strength test was 15x15x15 centimeters; the size of that for the antifreezing test was 10x10x10 centimeters; and the size of that for the percolation--resisting test was 15x15x15 centimeters.

6. The amounts of the plasticizers added are shown in table 6.

Table 6. Classified Number of Specimens and Amount of the Plasticezers Used

Plasticizer	Classified No Regular	Quantity Added (%)
Waste Liquor of Reed	Reed 1	0.05
	Reed 2	0.10
	Reed 3	0.20
	Reed 4	0.30
Sunflower Product	Sunflower 1	0.05
	Sunflower 2	0.10
	Sunflower 3	0.20
	Sunflower 4	0.30

Table Continued --

Pine-Leaf Product	Pine 1	0.05
	Pine 2	0.10
	Pine 3	0.20
	Pine 4	0.40
Rice-Stalk Product	Rice 1	0.05
	Rice 2	0.10
	Rice 3	0.20
	Rice 4	0.30

7. All specimens were preserved in moist chambers. The temperatures maintained were from 15 to 20° C. The relative humidity maintained was above 90 percent. The periods of preservation were seven days, 28 days, and 90 days.

IV. Plasticizing Effects of the Plasticizers

(1) Gelatinization of the plasticizers.

When plasticizers are added to the cement paste, two kinds of cement grains are formed: one is deposited with the vegetable matter which comes from the plasticizers; the other is the combination of the crystals of calcium hydroxide with that which has been deposited with the vegetable matters. Both grains carry negative charges of electricity and repel each other.

Therefore, all cement grains diffuse themselves uniformly. The cement paste does not coagulate. Such a phenomenon is spoken of as gelatinization. According to P. A. Wu-lieh-pin-chieh-erh-yuan-shih, the gelantinization is the first cause of the plasticizing effect of the plasticizers.

Such gelatinization can be illustrated by the sedimentation of the cement. Here are several 100 c.c. test tubes. One of them contains 100 c.c. of pure water, the other contains 100 c.c. of a 0.005 % solution of a gas, and each of the rest is full of a different plasticizer solution having a density of 0.05 %.

Add 10 grams of cement to each tube, shake the tubes vigorously, and then let them stand. The sedimentation of the cement in each solution can be observed.as follows:

In the test tubes which contain pure water and gas in solutions, the cement particles, which have diameters far larger than those of the cement grains themselves, settle rapidly. The liquids in both tubes are completely transparent after standing only five minutes, and a thin layer of cement which settled at the bottom of the tube can be seen.

But in the tube which contains the plasticizer solution, the cement grains generally maintain their original diameters and diffuse uniformly throughout the entire vertical space of the tube. The sedimentation is so slow that the solution remains opaque for a very long period.

The tube which contains waste liquor of reed appears transparent in one hour and ten minutes, that which contains the solution of pine-leaf product in 88 hours; but those which are full of sunflower and rice-stalk solutions take over 10 days to clear.

The gelatinization caused by the plasticizers increases the plasticity of the cement. The same plasticity can be maintained when the excess of water as well as the amount of the cement used are reduced. In addition, the gelatinization also means a better contact between the cement grains and the water. The hydration of the cement and the strength of the cement products are, therefore, improved.

(2) Plasticizers, standard consistency and the periods of the cement.

The cement grains of a cement paste are assembled together by molecular forces to form a structure in which

parts of the excess of water are confined. The formation of these structures is the setting of cement. Such setting of cement produces a certain ultimate displacement stress which prevents the cement paste from moving freely.

When the plasticizers are added to a cement paste, the vegetable matter of the plasticizers forms a gelatinous film around the surfaces of all the individual grains. The grains which have been covered by these films have more water around them than those which have not, and the water which is around the covered grains is stabler than that around the uncovered ones.

The molecular forces are subsequently weakened; the structures of setting are hampered, the water which is supposed to be confined inside the structures is let loose, and finally the fluidity of the cement is increased. Reduction of the standard consistencies of the cement can be seen from table (7).

Table 7. The Influence of the Plasticizers on the Standard Consistencies of Cement

Classified No	Regular	Reed	Sunflower	Pine	Rice
1	2.47	23.9	24.1	24.1	24.1
2	--	23.3	23.6	24.1	24.0
3	--	23.3	23.1	24.0	23.3
4	--	22.8	23.0	23.4	23.0

Furthermore, the gelatinous films formed of the vegetable matters of the plasticizers prevent the water from diffusing inside the cement grains. The preliminary phase of the cement hydration and the process of hydrolysis are both deterred.

In addition, the plasticizers contain carbohydrates which are composed of either five or six atoms of carbon. These carbohydrates have the effect of delaying the cement setting. This is why the period of setting for cement mixed with a plasticizer is longer than for the regular cement. If the amount of plasticizer used is over 0.2 percent, the period of setting of the cement is generally above the standard specified in the national code.

The effects of plasticizers on the periods of setting of the cement is shown in the table (8).

Table 8. Effects of Plasticizers on the Periods of Setting of the Cement

Classified No	Regular		Reed		Sunflower	
	Initial set h=m	Final set h=m	Initial set h=m	Final set h=m	Initial set h=m	Final set h=m
1	3:35	5:58	4:44	6:34	5:58	7:58
2	-	-	5:55	9:03	6:46	9:47
3	-	-	5:55	14:25	9:26	17:36
4	-	-	5:51	19:40	9:55	32:25

Pine		Rice	
Initial set h=m	Final set h=m	Initial set h=m	Final set h=m
4:53	6:51	4:30	8:17
5:47	8:48	5:23	8:56
6:27	11:52	7:21	10:01
11:57	32:21	9:36	13:46

(3) Plasticizers and the bleeding of the cement.

Bleeding of concrete or mortar consists of the forcing out of mixing water from the mass after molding. It is the result of sedimentation of the solid particles in the concrete or mortar. The water usually rising to the surface of the mold, softens the surface, lessens the affinity between the cement grains and therefore, ruins the homogeneity of the entire mass. Such expelled water also attaches to the aggregates and the steel reinforcements. The adhesion of the concrete to the aggregates and the steel is also weakened. Also, erosive liquids are apt to permeate the mass of the concrete through capillary channels formed by the expelled water.

D.I. Men-chieh-lieh-fu of the Soviet Research Institute of Industrial Chemistry, has drafted a formula in which he uses K to denote the percentage of water expelled:

$$K = \frac{A - B}{B} \times 100$$

A is the original volume of the cement paste,

B is the volume of the cement paste after shrinkage.

Disturb a cement paste which has a water-cement ratio of .55 and let it stand still for 3 hours. Mix it with plasticizer. The percentage of water expelled can be observed from the table 9.

Classified No	Regular	Reed	Sunflower	Pine	Rice
1	16.7	14.8	16.6	14.7	16.1
2	-	14.6	14.7	13.0	0.098
3	-	0.098	14.0	0.082	0.040

Table 9. Effects of Plasticizers on the Expulsion of Water of the Concrete

As a result of the experiment, the bleeding of mortar of concrete can be improved by the use of plasticizers. The gelatinization caused by the plasticizers splits the cement grains into minute particles. These minute particles, combining with water, form a great number of gelatinous compounds which prevent the water from being expelled.

(4) Plasticizers and the air content in the conrete.

When gaseous substances are mixed with a liquid and stirred, bubbles are formed. But ordinary liquid does not form many bubbles and the bubbles formed collapse readily. Plasticizers have the effect of lowering the surface tension of water to numerous air bubbles in the concrete from collapsing. It is these numerous minute air bubbles which increase the fluidity and workability of the concrete. The concrete can be molded or shaped at will.

Plasticizers different in the ability to lower the surface tension of water. Waste liquor of reed and the sunflower product have little ability to form air bubbles, but the ability of pine-leaf and rice-stalk products is extraordinarily high. If the quantity of the pine-leaf product or rice stalk product is over 0.2 percent, the quantity of air in the concrete is even above the standard that the concrete should contain. See table 10.

Table 10. Air content percent in the concrete which has been mixed with plasticizers. The maximum diameter of the concrete grain is five centimeters

Classified No.	Reed	Sunflower	Pine	Rice
1	0.9	0.8	2.4	1.3
2	1.1	1.4	3.7	2.7
3	1.9	2.0	5.6	6.5
4	2.5	3.1	6.8	9.2

These numerous minute air bubbles not only increase the plasticity of the concrete but also increase its durability. But if it is too much air, the strength of the concrete will be lowered and the favorable effect of the gelatinization of the plasticizers on the concrete strength therefore, reduced.

(5) Effect of plasticizers on the fluidity of mortar and concrete.

Plasticizers have another ability, that of improving the fluidity of mortar or concrete. It is this ability which reduces the quantity of water required for mixing. The reduction of required water is the ultimate aim of the use of plasticizers.

The fluidity of mortar is represented by its expansion. In an experiment we used water-cement ratio of .48, and cement-sand ratio of 1:3 by volume. Then mixed water, cement and sand together to form mortar. After the mortar was mixed with the plasticizer it was put on a vibrated thirty times. The expansion of mortar was measured as shown in the table 11.

Table 11. Expansion of Mortar in Centimeters

Classified No	Regular	Reed	Sunflower	Pine	Rice
1	135	141	142	148	141
2	-	152	146	154	158
3	-	157	158	192	186

Table 11 shows that the fluidity of mortar is increased with the amount of plasticizers used. This is so particularly with pine-leaf and rice stalk products which produce innumerable bubbles and have an emulsifying effect. The expansion caused by them is extremely noticeable.

The fluidity of concrete is generally measured by the slump. If the amount of water used is smaller than usually required for the same slump, it indicates that the

concrete is more fluid than ordinarily. In an experiment we conducted, the concrete used had a water-cement ratio of 0.65 and the slump was set at six to eight centimeters. The quantities of water used after mixing with plasticizers are shown in the table 12.

Table 12. Amount of water needed for the concrete which was mixed with plasticizers. (Kilograms per cubic meters)

Classified No	Regular	Reed	Sunflower	Pine	Rice
1	162	156	156	153	153
2	-	153	153	150	146
3	-	150	150	145	136
4	-	146	143	138	125

Table 12 shows the desirability of plasticizers. When the quantity of plasticizers added is 0.2 percent, the quantity of water required can be reduced by 7.4 to 16 percent. Not only is the amount of free water in the concrete greatly, reduced but the quality of the concrete is also greatly improved. The same water-cement ratio can be maintained while the quantity of cement can also be reduced by 7,4 to 16 percent. Plasticizers are therefore, economical.

Table 12 also indicates that the greates amount of water reduced is by the pine-leaf and rice-stalk products.

(V) Influence of Plasticizers on the Quality of the Concrete

(1) Influence of plasticizers on the strength of the concrete.

Use concrete which has water-cement ratio of 0.65. Set the slump at six to eight centimeters. After mixing with various plasticizers, the compressive strengths are shown in the table 13.

Table 13. Strength of Concrete which has been mixed with Plasticizers

Classified No	Amount of cement used Kilo-grams per Cubic meter	Air Content %	Compressive Strength at the age of 7 days kg/cm^2	%	Compressive Strength at the age of 28 days kg/cm^2	%
Regular	249		93.4	100	137.8	100
Reed 1	240	0.9	81.6	87.4	121.8	88.5
Reed 2	236	1.1	85.5	91.5	145.3	105.4
Reed 3	231	1.9	89.9	96.2	152.5	110.6
Reed 4	225	2.5	83.5	89.4	144.9	105.0
Sunflower 1	240	0.8	77.5	83.0	123.7	89.3
Sunflower 2	236	1.4	86.8	93.0	137.8	100
Sunflower 3	231	2.0	86.9	93.1	130.9	95
Sunflower 4	220	3.1	64.0	68.5	114.5	83.1
Pine 1	236	2.4	81.8	87.6	123.1	90
Pine 2	231	3.7	74.5	79.7	117.1	85.1
Pine 3	223	5.6	47.8	51.2	79.3	57.6
Pine 4	213	6.8	43.8	46.9	80.2	58.2

Table Continued --

Rice 1	236	1.3	83.6	89.5	153	111
Rice 2	209	6.5	76.8	82.2	129	93.7
Rice 3	209	6.5	65.2	69.8	74.0	53.7
Rice 4	193	9.2	49.3	52.8	67.3	48.8

According to a study conducted by Professor A. E. Hsieh-chin, when the vegetable matter is deposited on the surfaces of the grains, the sizes of the crystals formed during the process of the hardening of the concrete are greatly reduced. But the number of the crystals is greatly increased and longer periods of time are required for the crystal formation. These phenomena contribute greatly to the mechanical strength of the concrete.

However, such gelatinous films on the surfaces of the concrete grains deter the hydrolysis and hydration of the concrete. Furthermore, the film may form barriers preventing the cement grains from coming into direct contact with other grains. These phenomena affect unfavorably the strength of the concrete. If too much of the plasticizers is used, the films formed on the surfaces of the cement grains are too thick, and the reduction of the strength is especially apparent.

In short, the effects of placticizers on the strength of the concrete are both favorable and unfavorable. But reference to table (13) reveals that such effects vary with the plasticizers as well as with the amounts used. For instance, when the most favorable quantity -- 0.2 percent of waste liquor of reed or 0.05 percent of rice stalk product -- is used, the strength of the concrete could be increased by approximately 10 percent.

If the most favorable quantity (0.1 percent) of sunflower product is used the strength of the concrete is the same as that which has not been mixed with placticizers. But with the pine-leaf product, even if its most

favorable quantity (0.05 percent) is used, the strength of concrete is still somewhat less after 28 days.

Table (13) also indicates that for the most part the percentage of compressive strength at the age of seven days is less than 28 days. This gives a proof that at the early stage of the concrete, the effects of all plasticizers on its strength are unfavorable. These unfavorable effects are caused by the deterrence of hydration of the concrete. As stated before, thin films formed by the gelatinous matters deter the hydration.

The fact that the strengths of concrete are greatly weakened at the classified numbers: pine 3, pine 4, rice 3, and rice 4 of table (13) can be explained by the theory which was advanced by Russian Professor Ma-liu-ko in 19th Century. He maintained that the strength of concrete is determined by the ratio of the volume of the cement to that of the air bubbles. This theory has been generally accepted by contemporary students.

At the classified numbers: pine 3, pine 4, rice 3, and rice 4, the quantities of water required for the concrete are so lessened that the volume of the voids left by the free water in the concrete is reduced by 26 to 56 liters.

But the total volume of innumerable minute air bubbles is 56 to 92 liters. The voids increased is much greater than those reduced. This is why the strength of the concrete is noticeably weakened.

The effect of placticizers on the strength of the concrete also varies with the mineral constituents of which the cement is composed. According to Professor Pu-t'e, among the mineral compounds formed at incipient fusion, C_3S can be made strong by plasticizers. The strengths of other minerals are, on the contrary, reduced.

Because different cements have different mineral compositions, the effects of plasticizers on the strength of the concrete depend on the cement specimen used for the test.

(2) Percolation--resisting and anti-freezing

The sedimentation of solid particles in concrete forces water out of the mass after molding, leaving capillary channels. The number and shape of these capillary channels are responsible for differences in ability to resist percolation. If their number is great, their sizes laree, and their shapes straight, the resistance to percolation is low.

The purpose of plasticizers is to reduce the amount of water needed by the concrete while keeping fluidity constant. The condition of bleeding therefore can be also reduced.

In addition, plasticizers disperse the cement grains to form gelatinous compounds with water, thus preventing water from being expelled, reducing the number of capillary channels formed, and finally improving resistance to percolation.

With regard to damage to concrete from freezing, two theories were put forward. The first one, advanced by H. A. Po-po-fu, ascribes this damage to the movement of water. In his theory the concrete was considered to be cooled unevenly. Water from the less cooled part moves to the more cooled area and the amount of water in the more cooled area is greatly increased.

As a result of freezing, however, the innumerable and uniformly distributed bubbles prevent the frozen part from gaining more water. In this way the ability of the concrete to resist damage from freezing is improved.

The second theory was propounded by Pao-erh-ssu and was called the water pressure theory. He considered that when a concrete was frozen, the water in its capillaries encountered resistance and was prevented from flowing freely.

Water pressure in the capillaries was therefore, very high. But, if there were innumerable bubbles in the concrete, the water which was prevented from flowing might enter them. In that case, the water pressure could be lowered and the damage from freezing could be possibly reduced.

The two theories have one single conclusion which states clearly that the reduction of concrete capillaries as well as a certain amount of uniformly distributed bubbles both contribute to the ability to resist damage from freezing. Such conclusion has been verified by a great many tests.

Plasticizers not only reduce the number of concrete capillaries by the reduction of concrete bleeding, but also improve the concrete's ability to resist freezing damage by the formation of a certain amount of air bubbles.

Table (14) shows the strengths of concrete which was mixed with plasticizers and which was subjected to alternate freezing and thawing tests twenty-five times.

Classified No	Anti-freezing Strength From Tests: Strengths of Specimens				
	Regular	Reed	Sunflower	Pine	Rice
1	95	106	61.2	103	93.8
2	--	103	922	122	100
3	--	101	105	93.4	102
4	--	84	105	109	102

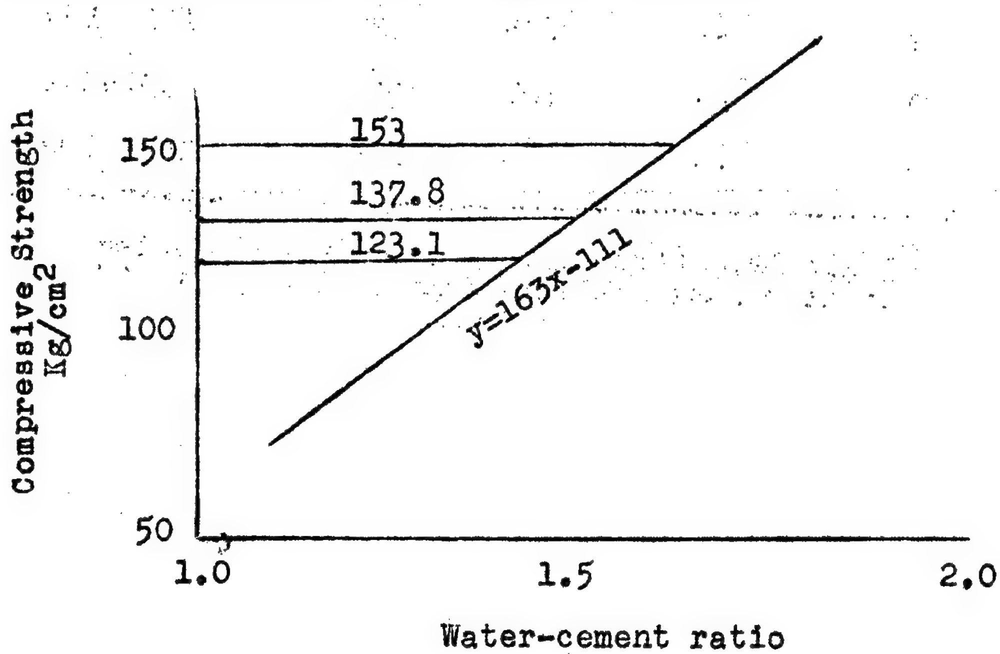
Table 14. Strengths of Concrete Subjected to Alternate Freezing and Thawing Tests 25 Times

(VI) Preliminary estimate of economic efficacy

When a suitable quantity of domestic plasticizers is used, they can reduce the amount of water needed by the concrete, reduce the quantity of cement used, improve concrete strength, and improve concrete durability. Their economic efficacy should, therefore, be considered on the basis of the total effects on the required water, strength, anti-freezing ability and resistance to percolation. But because the anti-freezing test has not yet come to a conclusion, such efficacy can for the time being be only preliminary estimated from the amount of water and the concrete strength at the age of 28 days.

We used water-cement ratios of 0.65, 0.75 and 0.85 to find a straight line which represents the relationship between the water-cement ratio and the compressive strength of a regular concrete at the age of 28 days. (see Fig. 2)

Figure 2. Relationship between water-cement ratio and compressive strength of a regular concrete



From Fig. 2 and table 13, we can get the amount of cement required for a certain standard No of regular concrete as well as that required for the same standard No. of concrete which has beeen mixed with plasticizers, as shown in table 15.

Table 15. Comparison Between the Quantity of Cement Required for a Regular Concrete and that Required for Concrete Mixed with Plasticizers

Standard No of Concrete	Regular Concrete		Concrete Mixed with Plasticizers	
	Water-cement ratios	Cement Required Kg/m^3	Names of Plasticizers	Quantity Percent
153	0.617	263	Rice-stalk	0.05
152.5	0.617	263	Waste liquor of reed	0.20
137.8	0.65	249	Sunflower	0.10
123.1	0.697	233	Pine-leaf	0.05

Concrete Mixed with Plasticizers		Reduction of Cement	
Water-cement ratios	Cement Required Kg/m^3	Kg/m^3	Percent
0.65	236	+27	+10.3
0.65	231	+32	+12.2
0.65	236	+13	+5.2
0.65	236	-3	-1.3

The economic efficacy is shown in table 16.

Table 16. Estimated Reduction of Expense per Cubic-Meter of Concrete

Names of Plasticizers				Waste Liquor of Reed	Sunflower	Pine-leaf	Rice-stalk
Reduction of Expense	Cement		Kilograms	32	13	-3	27
	Unit Cost		Yuan/Kg	0.1	0.1	0.1	0.1
	Total Cost		Yuan	3.2	1.3	-0.3	2.7
Increase of expense	Vegetable ingredients	Amount	Kg	-	4.54	1.82	2.5
		Unit cost,	Yuan/Kg	-	0.075	0.075	0.075
		Total cost	Yuan	-	0.34	0.136	0.188
	Fused Alkali	Amount	Kg	-	0.454	0.182	0.25
		Unit cost,	Yuan/Kg	-	0.6	0.6	0.6
		Total cost	Yuan	-	0.27	0.109	0.15
	Fuel	Amount	Kg	-	4.54	1.8	2.5
		Unit cost,	Yuan/Kg	-	0.023	0.023	0.023
		Total cost	Yuan	-	0.104	0.041	0.058
	Wages		Yuan	-	0.4	0.10	0.22
	TOTAL			0.156	1.114	0.386	0.616
	Profit and loss			+3.04	+0.19	-0.69	+2.08

Note: (1) The expense for hydrochloric acid, which is only 5 c.c. per cubic meter of concrete, is negligible.

(2) Waste liquor of reed is a by-product of paper manufacture. Its unit cost is very low and is assumed to be 15 yuan per ton (including transportation fee).

(3) The expense for manufacturing the plasticizers is estimated for small scale production.

(VII) Preliminary conclusions

(1) The solutions produced by boiling some plants with NaOH may have plasticizing effects on concrete and can be used as plasticizers. If the materials are suitable, the amount of cement required can be reduced and it is, therefore, an economical technique.

(2) The most favorable amount of plasticizer used varies with the plasticizers as well as with the cement. As results of the tests, the most favorable amounts of various plasticizers for No 400 silicate cement manufactured by the Cement Factory of China are shown in table 17.

(3) The maximum amount of plasticizers used should not be over 0.2 percent. Too much may not only cause a great reduction of concrete strength but also influence concrete stability.

(4) Plasticizers are very favorable to the durability of concrete.

Table 17

Names of Plasticizers	Most favorable amount Percent
Waste liquor of reed	0.20
Sunflower product	0.10
Pine-leaf product	0.05
Rice-stalk product	0.05

AN ANALYSIS OF THE TURBULENT WATER (KUN-SHUI) CONDITIONS OF THE FU HO, KIANGSI, CHIAO-MIEN TURBULENT WATER EARTH DAM

[The following consists of an excerpt of an article written by Kung T'ung-fu, appearing in the Shui-li Shui-tien Chien-she, No 17, September 1959, pages 28-35.]

Since the beginning of the great leap forward, much cement and steel has been required to build various structures, such as diversion dams, turbulent channls, and overflow spillways for the multi-purpose pattern of our water conservation system. To save such materials there is a trend toward building a new type dam, the overflow earth dam.

The design of such a new type will result in great economies. If there is nation-wide use of this new type dam for irrigation and hydroelectric power work, construction expenditures can be reduced and cement and steel, the inadequacy of which is painfully apparent, can be saved as well.

However, information about this type dam and the factors involved in its construction is thus far very scant. Deeper and wider inquiries of its problems remain to be made.

This article introduces the Kan-fu Plain aggregate development project in connection with a project for a turbulent water earth dam. The design of the dam, its construction and its condition of water turbulence are all included. It is the hope of the writer that this article may be a useful reference work for future designers of such dams.

Kan-fu plain is the site on which the largest aggregate project of irrigation in Kiangsi has been developed. This project benefits the entire region, consisting of the metropolitan area of Nan-ch'ang and its vicinity, Feng-ch'eng Hsien, Chin-hsien Hsien, and Lin-ch'uan Hsien.

The Kan-fu plain is the largest plain in Kiangsi. It is situated on the lower valley of the Fu Ho. A great dam of the Kan Chiang is to the west of it, Ch'ing-lan Hu to the east and P'o-yang Hu to the north. It covers an area of about 2,000 square kilometers, and has a cultivated area of 1,850,000 mou and a population of 1.1 million.

Being a hub of railways and highways, the Kan-fu plain possesses a great many good locations for industrial plants. It is a major political, economic, communications, cultural, industrial, and agricultural center of our country.

* * *

CONCLUSION

1. The turbulent water earth dam is a most recent type of dam to be used in our hydroelectric power enterprises. According to the experiment conducted by Ch'ing-hua University, it is categorically reliable. From the planning to the construction work, as well as the condition of water turbulence of this large dam, the results have also given a confirmation of its merit.

Its merit is sufficient to warrant great development. This large-sized dam we built has been successfully subjected to a hydraulic test. The test indicated that this type of dam can be used as a structure for carrying off flood water or the water of a reservoir. Under certain conditions the more expensive construction of overflow spillways can therefore be obsolete.

2. We have had much practice in constructing the Chiao-mien cross-river-channel dam, a turbulent water type. The results of such practice have indicated that a large-sized dam of this kind is not only efficient in carrying off a probable flood but can also be put permanently under water.

In this way, its ability to guide the turbulent water directly from the river to the irrigated lands is un-

questionable. A new way of saving cement and iron for use in the construction of hydroelectric power works has thus been discovered.

3. If the dam is put permanently under water the apron and the inverted filters along the downstream edge of the dam should be carefully designed. The continuous sissipation of energy [of the discharge] on the downstream side should be also carefully calculated.

The calculation of hydraulic force on the downstream side of this dam indicated that there was no ski-jump. The design of the downstream side was, therefore, relatively simple. In addition, the bed of the river was found to be a rock formation.

4. If a cross-river-channel dam of the turbulent water type is to be put under water permanently, and if the sand content of the upstream is great, No 110 concrete should be used for the dam crest as well as for its face plates. If both the sand content and the stream capacity per unit width are not great, the standard of concrete may be lowered to between No 90 and No 70; the dams' faces may even be made of cement-lime mortar or lime.

Recently we have designed an overflow embankment which will be built of cement-lime mortar.

5. The size of each concrete block for the faces of the Chiao-mien dam is relatively large--five by five meters. The thickness is 20 centimeters.

In the examination paper of Chin-hua University, the formula used for calculating the strength of the face of a dam is a formula for a cantilever with a slope of six horizontal to one vertical. We did not use this method to calculate the strength of the concrete faces of the Chiao-mien dam.

The faces of Chiao-mien dam were assumed to form one flexible flat beam. In this way when the thickness of the concrete blocks is kept constant, the size of each block can be relatively large. The large size of each block not only facilitates construction work but also

lessens the number of joints between the adjacent blocks.

No crack of the faces of the dam has developed although the dam has been subjected to torrents many times. Therefore, the practical method presented above represents a rational way of calculating the strength of dams having a height of 10 to 15 meters.

TEN YEARS' ACCOMPLISHMENTS IN WATER CONSERVATION AND ELECTRIC POWER CONSTRUCTION IN SHANSI

[This is a translation of parts I, II, and III of an article prepared by the Water Conservancy Engineering Bureau of the Shansi Provincial Department of Agriculture and Construction, appearing in Shui-li Shui-tien Chien-she, No 18, 26 September 1959, pages 18-20.]

As we welcome with enthusiasm the coming of the tenth anniversary of the founding of the state, the people who are fighting at Fen Ho, Su-shui Ho, Chang Ho, and the various water conservation and hydroelectric work sites are pleasantly and tensely laboring to welcome the great festival. They are contributing to the national day with practical acts.

The hydrologic, surveying, geological, and designing workers busy in such places as Wen-yu Ho, Sang-kan Ho, Chin-sha-t'an beyond the borders and Sha-hu-k'ou are again tensely making preparations for the engineering projects to be started next year.

Looking into the future of water conservation and electric power construction, a review of the experiences and lessons of the past ten years is of great significance.

At this moment we are very proud to make to the Party, and to the people of the whole country a general report on the brilliant achievements of our province in water conservation and electric power construction during the past ten years.

I.

What was the situation relating to water conservation and hydroelectric construction in our province before the liberation?

Before the liberation the foundation of water conservancy construction in our province was extremely weak. There was not a single hydroelectric power station in the whole province. At that time the whole province had an area of only 3,680,000 mou of land irrigated by well water, natural fountains and floods.

This constituted six percent of all cultivated land in the whole province. These irrigation facilities were, moreover, all located in a small number of localities on the banks of Fen Ho and Hu-t'o Ho.

Even these limited irrigation facilities were owned by the bureaucrats and the landlords. Moreover damage from war led to these facilities being in a state of bad repair. Only a little more than two million mou of land actually had access to irrigation facilities.

As a result our province suffered regularly from drought. Very often we could not sow in the spring because of the lack of rain, we could not preserve the seedlings in the summer, and we could not reap a harvest in the autumn.

Accordingly, Shansi was spoken of as an area where "there is a drought in nine out of ten years," and where "there is a drought in the spring and waterlogging in the autumn."

During the last one hundred years the province suffered three times from destructive drought: in 1867, 1920, and 1929 respectively. The land over an expanse of a thousand li was scorched. Families were separated. People even fed on one another. Conditions were extraordinarily tragic.

Before the liberation the province not only suffered from serious drought, but because in the mountainous regions the forests were destroyed in the attempt to reclaim wasteland, there was serious loss of soil. The lower reaches of the rivers silted and no control facilities were provided.

As a result each serious downpour of rain led to great floods from the mountain torrents, which produced great

calamities. Floods not only inundated cultivated fields, but also led to loss of life. Thus, along the banks of Fen Ho there was circulated the folk-song: "In the day the draft cattle worked the good fields; in the night the floods came and the land was laid waste."

In 1913 the Fen Ho breached its dikes at T'ai-yuan, inundating more than 1.6 million mou of farmland, affecting more than 380 villages, and causing the most terrible damage.

Because the calamities of drought and flood were frequent, the production and livelihood of the working people had no protection. In those days the older people always taught the younger people by these words: "Every year take precautions against drought. Every night take precautions against the wolf."

Even now the older people still have fresh memories of the past calamities of drought and flood. It is therefore not difficult to understand why water conservation construction developed so rapidly after the liberation; it is not difficult to appreciate the saying that "water conservancy is the life line of agriculture, and water is the blood of the crops."

II.

Drought is the greatest enemy of agricultural production in our province. Without water there will be no food grain. Thus victory over drought is the urgent hope of the people of the whole province. After the liberation the Party and the government immediately grasped this link in production increase. It was the time of the restoration of the national economy. Conditions were very difficult for all undertakings, but the state exerted very great effort at water conservancy construction.

On the one hand we restored, reorganized, reconstructed, and expanded the original water conservation facilities and actively developed small-sized water conservancy projects which cost little and brought immense benefits.

On the other hand we started on medium sized water conservancy projects.

As early as 1949, when the bandit Yen was still occupying T'ai-yuan, the original North China People's Government had dispatched a surveying corps to investigate and survey the irrigation projects at Hu-t'o Ho and Hsiao Ho. Soon afterward in 1950, the former Ministry of Water Conservancy organized the inspection and the guidance of the work by Soviet expert Comrade Pu-ko-fu and others on the dams for Hu-t'o Ho and Hsiao Ho.

At that time we started the construction of the two modern water conservancy projects in our province. They were completed in 1951 and 1952 respectively. In 1950 we also reconstructed the irrigation facilities of Sang-kan Ho and reconstructed and expanded the irrigation facilities of Hun Ho.

As we entered the period of the First Five-Year Plan for the Development of the National Economy, we started a planned movement for the development of water conservancy in several major areas.

During the five-year period we constructed 217,000 small engineering projects and completed 47 water conservancy projects of larger sizes. These projects greatly promoted the development of agricultural production at the time. They began to bring about a transformation of the natural faces of their respective areas.

In 1958 we entered the period of the Second Five-Year Plan. This was a year of the greatest significance in the history of water conservancy and hydroelectric construction in our province. The Provincial Committee sent out toe call to fight hard for three years to change the face of the entire province.

The people of the whole province responded. They developed the Communist characteristics of daring to think and daring to act. They were determined to conserve the water from the sky, to retain the water on the ground, and to bring out the water from underground.

The people fought hard in the severe winter. They battled the rainy season. In addition to completing large numbers of small sized water conservancy projects, they also completed 111 larger water conservancy projects (some not fully completed). These projects involved 40 million cubic meters of earth and stone work. The full completion of these projects will provide irrigation facilities for 2,220,000 mou of land.

These projects include the following: the Hun-yuan Tang-yu Po-kung-pa Reservoir with dams 64 meters high; the Hui Ho Reservoir with a water conservation capacity of 75 million cubic meters; the Hung-chao July First Canal, 150 kilometers long and conducting water up the area; the mountain canal at Po-lan-yen, Ping-shun, built on a high precipice; and the Tun-chiang August First Reservoir and Wu-chai Nan-feng Reservoir both constructed with the cooperation of the military and civilian populations.

All these projects have been gigantic and difficult, but they all have been conquered by the strength and wisdom of the broad masses of the people. It is truly a case of making "the mountains bow their heads and the waters give way."

The big leap forward in water conservancy construction in 1958 and the realization of communalization throughout the province laid sound foundations ideologically, organizationally, and materially for the construction of large sized water conservancy projects in our province on a larger scale.

Accordingly in 1959 water conservancy and hydroelectric construction has continued to leap forward. The large reservoir of the Fen Ho -- to which we have looked forward for a long time -- will start to retain the flood waters and to conserve water during the year.

We have also succeeded in the method of building high dams (40 meters) by pouring earth into the water. We have also developed on a large scale the work of harnessing the Su-shui Ho and the Chang Ho basin in the Tai-hang Shan area, both of which have been scenes of repeated calamities. In addition many engineering projects are

already under construction, while many more are being prepared.

III.

During the past ten years, we have not only completed many engineering projects but also in the course of our actual struggle built up a technical force and gradually arrived at a clear understanding of the policy for water conservation.

Water conservancy work has changed from a former situation in which we feared the water and paid major attention to draining water to a new one in which we love the water and pay major attention to conserving it. The former situation in which official projects predominated in the water conservancy field has been changed to the present situation in which the masses carry out the major share of the water conservancy work.

From arrangements for single projects we have progressed to attention to whole river basins and to the systematic planning of many projects, covering the plains and the mountain areas and seeking the overall basic harnessing of the waters.

From seeking simple uses of the water, we have developed to the stage where we are undertaking the comprehensive utilization of the water. Irrigation is the basic consideration, but also included are flood prevention, power generation, navigation and pisciculture.

From the exploitation of single sources of water supply we have progressed to the combined utilization and regulation of water sources both on the ground and underground. The people in their actual practice have mastered the laws governing the above mentioned activities.

During the ten year period the state has helped with investments and loans totaling 210 million yuan and Soviet experts have given guidance in advanced techniques. Thus our province has made unprecedentedly great achievements in all aspects of water conservancy and hydroelectric construction.

During the past ten years we have constructed more than 628,000 small sized water conservancy projects and 172 large and medium sized water conservancy projects. We have completed more than 9,000 bridges, culverts, cisterns, and cascades.

The large and medium sized projects mentioned above involved 83.5 million cubic meters of earth and stone work. The projects expanded and improved irrigation facilities for an area of 7,340,000 mou, and provided a water conservation capacity of 940 million cubic meters.

Among these, projects with dams more than 25 meters high or with a water conservation capacity of more than 10 million cubic meters include the following: the reconstruction of the second and third dams of Fen Ho; the dredging and construction of the water courses of Hsiao Ho, Hu-t'o Ho, Sang-kan Ho, Hun Ho, Yu Ho, Yang-wu Ho, Tse-yuan Canal, Hsiang-fen "Leap Forward" Canal, and Hung-tung "July First" Canal; the construction of the reservoirs of Fen Ho at Hsia-shih-chia-chuang, Hui Ho at Hou-ma Shih, Tung-chiang at Chang-chih Shih, Yang-po at Lin Hsien, Nan-feng at Wu-chai, Tzu-liang at Shan-yin Chen, Kuo-pao at Tai-ku, Ti-shui-yen at Tso-yun, Hou-chuang at Fan-chih, Chao-chia-k'ou at Shuo Hsien, Shen-ts'un at Chang-chih, Hsi-pao at Hu-kuan, Tu-chia-ho, Yueh-ling-shan at Ch'in Hsien, and Hsia-pei-li.

The construction of these large and medium sized water conservancy projects has led to the control of water sources over large areas and has provided greater capacity for the conservation and regulation of water supply. It has guaranteed the irrigation of farmland in the dry season and thus played a decisive role in the transformation of the water supply situation of a whole river basin.

The Fen Ho Reservoir is the largest. On its full completion, it will exercise control over an area of 5,300 square kilometers on the upper reaches of the river and have a water conservation capacity of 700 million cubic meters. It will basically remove the threat of the Fen Ho flooding the T'ai-yuan Municipality, reduce the calamities produced by floods in the Central Shansi basin, and guarantee the timely and adequate irrigation

of 1.3 million mou of farmland in central Shansi. In addition it will supply water for the industrial and consumption needs of the T'ai-yuan Municipality.

Furthermore, a hydroelectric power station with a capacity of 9,000 kilowatts will be constructed at the Fen Ho reservoir. This power plant will be linked with the electric power network of T'ai-yuan so that thermal power and hydroelectric power will supplement each other. The rural areas in the neighborhood will be electrified.

In 1959 simultaneous with the battle in the north against Fen Ho, we are also carrying out the "southern expedition against Su-shui Ho. The harnessing of the rivers in this area had started in 1950, but at the time we only attended to the prevention of flood and the drainage of waterlogging.

Since 1956 we have changed this policy and have progressed to the stage where water conservation has been made the major goal and attention is paid to both conservation and drainage. This year more than 30,000 heroes are continuing the battle in this area.

After a difficult struggle, we have completed seven reservoirs, including the Chang Liang and Yu Wang reservoirs. We are at present constructing the Shang Ma, Lu Chuang and other reservoirs. We are also carrying out designs for the whole basin. These include plans for soil preservation and afforestation in the upper reaches, arrangements for the major projects of the trunk water courses, improved utilization of low lying and alkaline land, for the high altitude irrigation project to conduct the waters of the Yellow River to the area, for the Su-shui embankment and drainage project connected with the San-men Gorge Reservoir, and for the development and utilization of underground water.

The people have put up such great zeal and have devoted such a long period of time to the harnessing of Su-shui Ho because, with the full completion of all the projects mentioned, the annual output of sodium sulphate will come up to 70 percent of the total national output.

At the same time we shall definitely preserve the salt sea of Yun-cheng, a base for the chemical industry with its large output of salt. Furthermore, the Tung-pu Railway will be spared from inundation during the flood season.

The completion of all the projects will also provide irrigation facilities for nearly two million mou of farmland; five million mou of farmland will be freed from the threat of floods; and 500,000 mou of alkaline soil may be gradually improved and utilized.

Furthermore, after the conservation of water, we may also develop pisciculture, electric power generation, and navigation, and thus bring good fortune to the people of the entire basin.

During the past ten years we have earnestly and thoroughly implemented the principles of "preparedness against calamity and paying greater attention to prevention than emergency relief measures," and the policy of combining flood prevention with irrigation promotion. We have completed more than 150,000 flood prevention and drainage projects of a mass nature and have given protection to 149 cities and towns, 1,845 villages, and more than 12 million mou of land.

We have carried out the dredging and harnessing of such key rivers as Wen-yu Ho, Su-shui Ho, Yu-yu Ho, and Yao-jung Canal. We have strengthened the embankments of the Fen Ho at T'ai-yuan Municipality and the Tao Ho at Yang-chuan Municipality; and we have carried out flood prevention projects at Ta-jen-yu-k'ou, Ling-shih-cheng-kuan, Wen-shui-hsi-she, and Tso-chuan-ma-tien.

Simultaneous with the harnessing of the major rivers, we have also constructed flood prevention projects on the side of the mountains at Taiyuan Municipality, Tatung Municipality, and Chang-chih Municipality. We have thus raised the flood prevention and flood water drainage standards of the rivers and prevented flooding by mountain torrents, thus guaranteeing industrial and municipal construction in the above named cities.

We have also developed education among the broad masses on the prevention of the danger from mountain torrents. Our province has seen a marked decrease in such calamities as the landslides and the collapse of kilns in the extensive rural areas in the mountainous districts.

Simultaneous with the large scale development of water conservancy projects, our province has also registered great development in the rural areas in the field of hydroelectricity.

In 1955 the first hydroelectric power station in our province was constructed--the Ming-chiang Hydroelectric Power "Station at Hung-tung. Since then a total of 113 hydroelectric power plants have been constructed in the rural areas of the province, with a total generating capacity of 2,449 kilowatts.

We have also built 200 power stations generating 3,520 kilowatts. There are 13 hydroelectric power plants with equipment of a capacity of more than 40 kilowatts, and they include those of Kuang-ling-shen-tang, Ping-ting-niang-tzu-kuan, Shan-yin-chen-tzu-liang, and Chih-hsiu-hung-shan.

The construction of these electricity plants and power stations has provided cheap electricity and power for the development of irrigation at high altitudes, flour milling, oil pressing, processing operations of agricultural side-line undertakings, lighting for the rural areas, and for local industries such as iron smelting and timber processing.

The hydroelectric plant at Shih-ts'un, Hung-tung Hsien, has a capacity of 38 kilowatts. From September to the end of 1958, a period of three months, the plant was responsible for the ginning of 700,000 chin of cotton and the milling of 420,000 chin of flour.

This economized 13,675 man-days and 2,615 head-days (of animal power). The income and the savings together totalled 21,800 yuan, which was equal to 124.5 percent of the total investment of 17,500 yuan in the plant.

Because the investment was small and the benefits huge, Hung-tung Hsien in 1958 brought forward the slogan of the development of electricity by all the people. The people of the whole hsien exerted efforts, manufactured their own electricity generating machinery, produced their own accessories and tools for processing, saved their own capital, and procured their own raw materials. They have now constructed 37 hydroelectric plants, generating 416.5 kilowatts, and 54 power stations, with a total of 1,222 horsepower. They have unfolded the beautiful future of building socialism in the rural areas.

We have attained such speed in hydroelectric development principally because we have thoroughly implemented the policy of "paying major attention to small sized projects, making the people's communes undertake the major efforts, making production the major objective, and giving priority to power before electricity."

We have further adopted the policy of reliance on the mases, breaking down superstition, drawing supplies from local sources, using both native and foreign methods, and walking on two legs.

As the result of the development by all the people of projects for generating electricity, we have discarded the superstitious viewpoint which attached mystery to electricity. We can manufacture ourselves native electricity generating machines, small sized water turbines and such hydroelectric equipment. More people have mastered hydroelectric techniques. In Hung-tung Hsien there is the Red Scarf Hydroelectric Plant which has been built by children.

During the past ten years, in the course of our completion of various water conservancy projects, our province has accumulated rich data on basic tasks relating to investigating and surveying water conservancy projects, designing, geological surveys, and hydrological studies.

In designing we have carried out designs for whole basins for 16 major rivers, including Fen Ho, Sang-kan Ho, Hu-t'o Ho, Ching-chang Ho, Ch'in Ho, Hsin-shui Ho,

and Su-shui Ho. The area covered by these desings totals 135,000 square kilometers, constituting 86 percent of the total area of the province.

In surveying and cartography, we have completed topographical surveys of 16,400 square kilometers, linear surveys of 128,324 square kilometers, and general soil surveys of 18,300 square kilometers of the scale of 1/1000,000.

Regarding the investigation of underground water sources, before 1958 we had carried out the investigation and surveying of water sources in the cities of T'ai-yuan, Ta-tung and Chang-chih. The work has given effective support to the industrial development of these cities.

We have also achieved many results in geological surveying, soil experimentation, and soil analysis.

Hydrological observation is the vanguard of water conservancy construction. During the early period of the liberation, our province had only one hydrological station. Today the province has constructed 68 stations for the measurement of waterflow, 311 rain-gauge stations, and eight stations for experiment on cross currents. Hydrological observation stations are scattered over practically all the rivers of the province.

The data from observations and analyses made by such stations are supplied to industrial and mining enterprises and cities and communications enterprises of the province. We have also achieved good results in the utilization of these observation stations for the forecasting of floods and droughts. They have played a great role in flood prevention and drought prevention in the province.

During the past ten years, through our practical efforts at water conservancy construction, scientific and technical levels in the water conservancy field in our province have been greatly raised.

We have also many achievements in this connection. They include designing and planning of irrigation areas, improvement of alkaline land, dam construction by pouring

earth into the water, dam construction with guided explosions, oxygen explosion, and the construction of reservoirs with different types of dams. We have accumulated rich experiences in these fields.

In constructing the Fen Ho Reservoir we used the method of pouring earth into the water and successfully built an earthen flood retention dam 40 meters high. It is one of the tallest dams in the whole world to be constructed by this method. The experience gained will contribute greatly to designing theory for this dam construction method.

In fostering technical personnel during the past ten years, the state has resorted to such measures as training them in schools and sending cadres for advanced studies. As a result the technical force of our province has greatly expanded. At the time of the liberation we had only a few more than 40 technicians. Today there are already 750 water conservancy technical cadres of a medium level and above in our province. In addition we have also trained more than 50,000 peasants as technicians in water conservancy and hydroelectric projects through the operation of training courses and practical studies at the work sites. They are now capable of taking up one or more technical tasks connected with surveying, prospecting, actual work, machine operation, and electrical operation. Through the expansion and consolidation of our technical force, and through the accumulation and enrichment of water conservancy knowledge year after year, we have step by step understood and mastered the objective laws of nature.

GREAT ACCOMPLISHMENTS IN WATER CONSERVATION CONSTRUCTION IN HEILUNGKIANG IN THE PAST TEN YEARS

[This is a translation of an article written by LI Chi-ch'eng, Director of the Ministry of Water Conservancy of Heilungkiang Province. The article appears in Shui-li Shui-tien Chien-she, No 18, 26 September 1959, pages 23-25.]

Water conservation construction in our province has registered brilliant achievements in the various fields of farmland irrigation, flood prevention, control of waterlogging, soil perservation, and hydroelectric power development in rural areas. This is the result of ten years of development with three hightides in the course of progress--realized under the correct leadership of the Central Committee, the [Heilungkiang] Provincial Committee of the Party, and the Provincial People's Council; with reliance on the leadership of Party and government organs at different levels; and through the joint efforts of the people of the whole province.

During the past ten years, we completed 900 million cubic meters of earth and stone work. Large and small water conservation projects are scattered over all areas in the province. These projects have manifested their great role in irrigation, flood prevention, control of waterlogging, and resistance against drought.

During the ten-year period we successfully overcame three droughts and four floods. The irrigated area was increased by 800 percent, and flood and drought calamities were reduced to a marked degree. We have continually raised the volume of production and promoted the rapid development of agricultural production.

In the field of farmland irrigation, we have constructed nearly 6,000 reservoirs of medium and small sizes. We have created over 1,000 irrigation areas, dug over 4,500 kilometers of irrigation canals, constructed over 4,900 watercourse to conduct the flow of water, and sunk over 130,000 wells. The existing irrigation facilities are capable of

irrigating 15,130,000 mou of paddy fields and dry fields (this year only 10,670,000 mou are irrigated because of drought and shortage of water supply). This is eight times the irrigation area developed during the 40 years before liberation. This area of paddy fields is four times that before liberation.

More important still is the fact that, whereas in the past only a small number of peasants of Korean nationality worked paddy fields, today paddy fields are extended all over the province and are to be found in practically every hsien. Even in the Hei Ho area north of 48 degrees north latitude, where the Japanese imperialists had in the past definitely stated paddy fields could not be cultivated, such fields are being extensively developed. A good foundation has thus been laid for the large scale development of paddy fields.

Simultaneous with the active development of paddy fields, beginning in 1956 we exerted all-out efforts in the sinking of wells for the watering of fields. After active efforts and a gigantic struggle, the area of watered fields in the province has, at present, reached 7,340,000 mou.

Production increase has been marked. For example, in the Big Bumper Harvest Administrative Area of the Hsien-feng People's Commune in An-ta the output of wheat per mou reached 303 chin after receiving benefits from irrigation. The output per mou from areas without irrigation benefits is only 70 chin.

Production increase experiences in different localities have proved that the irrigation of dry fields is not only a basic measure to resist drought, but is also an important means of production increase. There are innumerable instances of the multiple increase of production as the result of timely and adequate irrigation.

During the years 1958 and 1959 our province suffered continuously from serious drought. Under the leadership of the Party the people of the whole province mobilized all forces which could be mobilized, utilized all water sources which could be utilized, and developed large scale struggles againts drought.

In 1958 we watered and irrigated 12 million mou of farmland, and in 1959 we irrigated more than 10 million mou of farmland. Even under the conditions of more serious calamities we guaranteed the realization of the big leap forward of agricultural production increase.

In the fields of improvement of low lying areas and control of waterlogging, during the past few years the province newly constructed, expanded or restored to good repair 3,800 kilometers of trunk and branch canals for the drainage of water. We constructed more than 200 larger sized culverts and other structures. We also carried out a large volume of engineering projects in the building of reservoirs and dams and in the field of soil preservation. To varying degrees damage from waterlogging was reduced and bumper harvests secured over the 14 million mou of farmland throughout the province.

In Hai-lun Hsien, for example, several hundred thousand mou of farmland had in the past "suffered from a serious calamity in a heavy rainfall, suffered from a minor calamity in a small rainfall, and experienced waterlogging nine years out of ten."

After efforts in 1958 to dredge a network of waterways and to repair reservoirs on the plains, waterlogging was basically eliminated. Since June of this year the area had incessant rainfall; but because a good job was done in the control of waterlogging, the crops grew luxuriantly, and there was a scene of a bumper harvest.

In Shih-pa-li Tien-tzu in Wu-chang Hsien, waterlogging occurred every year, production volume was low, and the masses lived in poverty. Before 1957, the state had to subsidize the area with from 800 to 900 tons of foodgrain each year. In 1958, water conservation projects were developed with vigor, and the low lying land was converted into paddy fields. Immediate results were reported, and a bumper harvest was achieved the same year. Not only was state relief no more needed, but the district also sold to the state 230 tons of its surplus grain.

Similar instances have been numerous. During these past years, we have had more successful experiences in our fight against waterlogging. They include the repairs to

reservoirs on the plains, the dredging of networks of watercourses, and the conversion of low lying land into paddy field. We have laid the good foundation for our future efforts in the improvement of low lying land and the control of waterloging.

In the field of flood control and prevention, during the past ten years the state and the masses put up large amounts of manpower, material resources, and financial resources. Along the 72 principal rivers of the whole province, we have restored and newly constructed dikes to the total length of more than 4,300 kilometers. We successfully fought against four floods, in 1951, 1953, 1956 and 1957 respectively. The flood in 1957 was the biggest since hydrological records were kept. But we finally overcame this especially large flood, thanks to the leadership of the Central Committee and the Provincial Committee [of the Party], the all-out support from fraternal provinces and municipalities, and the hard struggle put up by the people of the whole province.

We safeguarded the extensive farmland in urban and rural areas and the life and prprty of the masses of the people, and we achieved a great victory in the struggle for the prevention of the flood. It was a brilliant page in the history of our province. The broad masses of the people expressed unbounded gratitude to the Party and the government.

We may here review the flood of 1932, under the rule of the enemy and the puppet regime. At that time the water level was lower than that of 1957. The whole area of Harbin was inundated. All along the river there was an expanse of water. Huge losses were created. In the area above Harbin alone, 11,500,000 mou of farmland were inundated, tens of thousands of people lost their lives, and hundreds of thousands were made destitute.

Thinking of the past and looking at the present, we may further understand the great historical significance of the people's victory over the flood under the leadership of the Party.

In addition, during the past few years we have also made great achievements in soil preservation, the development of hydro-electricity in rural areas, and in the

promotion of meteorological and hydrological activities. These have played a great role in the development of industrial and agricultural production in the rural areas, in the improvement of the people's livelihood, and in the enlivening of cultural activities in the rural areas.

Special mention may be made of the fact that simultaneous with all-out efforts at the development of small sized water conservation projects we have also started preparations for the harnessing of the large rivers. By now we have basically completed designs for whole basins for the watercourses of the Sung-hua Chiang [Sungari], the Mu-leng Ho, and the La-lin Ho. We have started the planning of the immediate projects [connected with these designs]. Work has started on the Sino-Soviet Joint Comprehensive Survey of the Heilungkiang.

Work now carried out on the La-lin Ho will be included in the first-stage projects for the harnessing of the Sung-hua Chiang. The Lung-feng Shan Reservoir in the basin will be basically completed before National Day. Work will soon start on the Tao-shan Reservoir and the Lan-kang Hydro-electric Power Station. Preparations are under way for the immediate commencement of work on the Ta-lai Reservoir on the Nun Chiang. When these various projects are brought into full operation, we shall further transform the situation of suffering from water into that of benefiting from water and create good fortune for the people of the whole province.

Generally speaking, just as in the cases of other socialist construction enterprises in the rural areas in our province, water conservation construction in the province has gone through an abnormal ten-year period. The actual conditions show that the ten-year period achieved more than one hundred years had in the past; and, in each of the [ten]years, we did better than what was done in ten years in the past.

The water conservation projects we completed during these ten years were several times--and even scores of times--those completed in the thousands of years of previous history. And furthermore, since 1958, the volume of earth and stone work completed in less than two years has constituted 90 percent of the total work volume of the past ten years and more, while the increased area of irrigated land was nearly three-fourths of all such increases.

This fully shows that water conservation construction in our province has principally realized its unprecedented development under the stimulation of the big leap forward, being spurred on by the movement for the building of people's communes. Thus, the gigantic achievements in water conservation construction have been the great victories of the general line, the big leap forward, and the people's communes. Tracing it to the root, they are victories of the leadership of the Party.

Since the big leap forward we have registered great achievements both in the speed and the scope of water conservation construction. But more important still, we have found the correct policies and measures in water conservation construction, steeled our caderes and the masses, and expanded the force engaged in water conservation work.

During the past ten years we cultivated more than 100,000 peasants into technical personnel and workers through training and actual practice. We have thus initially solved the difficulty of lack of technical forces for water conservation construction.

During these years our basic experiences in achieving the big leap forward in water conservation construction are as follows:

(1) We must strengthen the leadership of the Party and persist in letting politics assume command. We must rely on the leadership of the Party, strengthen political and ideological work, tightly grasp the weapon of the general line, and continually overcome rightist thinking.

In our concrete work we must fully develop our initiative and at the same time evaluate objective possibilities. We must fully develop the revolutionary activism of the broad masses and continue to exert the utmost effort to press forward vigorously.

(2) We must thoroughly implement the mass line and develop strenuously the mass movement. The close combination of leadership, the masses, and techniques constitutes an important work method in the promotion of the water conservation movement. This calls for "the leadership to penetrate the ranks, the cadres to take the lead and establish themselves as models, and the summarization of

experiences." We must also be adept at taking a free hand in the organization of the masses; in the development of blooming, contending and debating; in the convocation of on-the-spot conferences for the interchange of experiences; in the organization of comparisons and competitions; and in taking a tight grip on the two ends in order to lead the middle forces. These measures will mutually promote and mutually elevate different forces. We must further stress the need to publish our techniques and to mobilize the masses to discuss them so that all techniques are provided with an extensive popular base.

Generally speaking, the all-out development of the mass movement must be combined with the strengthening of technical management. The moblization of the masses with a free hand must be combined with the conducting of experiments for all measures. Sky-rocketing zeal must be combined with scientific techniques. Developing production must be combined with improving living conditions. Labor must be combined with leisure. All these are important factors for the proper development of water conservation construction.

(3) The overall and correct implementation of the "three major" policy is the fixed and unshakable policy in water conservation construction in the future. In the all-out development of water conservation construction in the future, we must thoroughly implement the principles of local expediency, comprehensive harnessing, and comprehensive utilization.

We must thoroughly practice the method of "walking on two legs;" that is to say, we must rely on the strength of the masses and the communes and combine this strength with appropriate help from the state. We must combine large projects with medium and small projects; we must combine measures for conservation with measures for drainage; we must combine measures for unearthing of existing engineering potentials with measures for new engineering projects; we must combine permanent projects with temporary projects; we must combine the utilization of water above the ground with the utilization of water underground; and we must combine native methods with foreign methods.

(4) We must fully implement the policy of achieving quantity, speed, quality, and economy in water conservation construction. Just as in other items of capital construction, a long range view must be taken in the development of water conservation projects. Quality must come first. The guiding principle must consist of the overall implementation of the policy of achieving quantity, speed, quality and economy.

It is not correct merely to seek quantity and speed to the neglect of quality and economy. Nor it is correct merely to seek quality and economy to the neglect of quantity and speed. Such thinking and methods place excessive emphasis on one side and overlook the other side.

Accordingly, in our actual work we must stress both consolidation and development, both quantity and quality, and both construction and management and maintenance. We must particularly implement the principle of "dealing with projects to last a hundred years where quality is the first consideration," in the handling of the medium and large projects and the larger reservoirs.

We must strictly observe the procedure laid down in plans and in technical work rules. We must persist in the system of inspection and examination before delivery. We must carry out water conservation construction with the guaranteeing of both quality and quantity.

During the past ten years, our achievements in water conservation construction have been gigantic. Of course, because of our lack of experience and the inadequacy of our technical force, we faced unavoidable defects and problems in the course of our actual work. For example, some local plans set forth targets which were excessively high and the quality of some engineering projects were a little inferior. These are problems in the midst of progress. The comparison of these problems to the achievements in water conservation construction is merely like the comparison of ten fingers to one finger.

Nevertheless, we have adopted the attitude of seeking actively the correction of these problems. Some have been corrected; some are being corrected; and, in the future, all will surely be corrected.

However, the province had in the past a weak foundation in water conservation, and the area under irrigation was small. The harnessing of the large rivers has only just started, and the rich water resources of the province are not yet fully utilized. The existing water conservancy measures are from adequate to mullify the threats presented to agricultural production by floods and droughts.

Nor are they adequate to cope with the demands of the over-all development in agriculture, forestry, animal husbandry, sideline production, and fishing following the communalization of the province. In a word, we have not yet negotiated the hurdle.

It is therefore necessary that we grasp the present opportunity; and continue our efforts to bring about an even greater upsurge in water conservancy construction during the current winter and the coming spring. This is the demand of the big leap forward in agricultural production. It is the aspiration of the broad masses of the people.

The present situation is most favorable to our efforts to vigorously develop water conservation. The resolution of the Eighth Plenum of the Eighth Central Committee of the Party and the general line have roused the fighting spirit of the people of the whole country.

New upsurges in the movement for production increase and construction enterprises have emerged in large numbers. After the overhauling and consolidation of the people's communes, the activism of the masses for production has risen higher, and their power for the conquest of nature and the achievement of greater bumper harvests in agriculture has grown larger and larger. Their enthusiasm for the vigorous development of water conservation projects has grown stronger and stronger. All these are favorable factors for a new upsurge in water conservation construction in our province.

All we have to do is to strengthen the leadership of the Party; develop vigorously the mass movement; properly summarize and popularize the experiences in water conservation construction; and earnestly implement the policies of the combination of the large, medium, and small projects and of "major attention to the three key problems."

In accordance with the conditions relating to manpower, material resources, and financial resources in our province, we must at the moment pay major attention to medium and small water conservation projects, actively prepare for large projects, and implement thoroughly the policy of walking on two legs.

It is, therefore, not only necessary but also entirely possible for us to bring about a new upsurge in water conservation construction during the coming winter and next spring.

The preliminary arrangements for water conservation construction during the coming winter and next spring are as follows: In the whole province, irrigated area is to be increased by between 10 million and 15 million mou, bringing the total area of irrigated land next year to between 25 million and 30 million mou (with from eight million to 10 million mou of paddy fields), or from 25 to 30 percent of all cultivated land in the province. This calls for the completion of about 300 million cubic meters of earth and stone work, a very glorious and difficult task. This is the continued leap forward in water conservation construction.

In order to victoriously fulfill this mission, we must penetratingly study and implement the spirit of the Eighth Plenum of the Eighth Central Committee of the Party. Through this we shall overcome rightist feelings. We shall continue to exert the utmost effort, develop vigorously the mass movement, and rationally deploy labor power.

We shall organize specialized work forces. We shall organize socialist cooperation and mutual support under the principle of mutual assistance and mutual benefits with the sharing of rational responsibilities. We shall grasp tightly the measures for surveying and planning, and for the preparation of material supplies. We shall undertake vigorously the reform of work tools. We shall, especiallly, undertake properly the preparations for work to be started in the winter. With all these measures we shall greet the greater new upsurge of water conservation construction during the coming winter and next spring.

EXPANSION OF EARTH DAM TECHNIQUES
IN CHINA DURING THE LAST TEN YEARS

[This is an excerpt of an article prepared by KU Chin-ch'en, appearing in Shui-li Shui-tien Chien-she, No 18, 26 September 1959, pages 32, 33, and 41.]

During the past ten years, and particularly with the big leap forward of 1958, earth dam construction techniques in our country saw great development along with the leaping progress in water conservancy and hydroelectric construction. Major earth dams constructed or under construction include the following:

Shih-man-t'an, Pan-chiao, Pai-sha, Po-shan, Nan-wan, Kuan-t'ing, Ta-huo-fang, the dams on the two banks of Tan-chiang-k'ou, and the Grade I [dams] at I-li Ho, Mi-yun, Kang-nan, and Che-lin. Medium and small dams constructed in different localities number tens of thousands.

With the accumulation of experience in dam construction, the height of earth dams has increased annually. The work volume has increased annually. Larger earth dams constructed before 1955 are shown in the following table with their heights and the volume of engineering works.

Engineering Project	Type of dam	Height (meters)	Engineering work volume (unit 10,000 cubic meters)
Shih-man-t'an Reservoir	earth dam	25	80
Pan-chiao Reservoir	earth dam	27	480
Pai-sha Reservoir	earth dam	47	500
Po-shan Reservoir	earth dam	40	250

Table continued--

Nan-wan Reservoir	earth dam	35	340
Kuan-t'ing Reservoir	earth dam	45	100

The heights and engineering work volumes of larger earth dams constructed from 1955 thru 1958 are given in the following table:

Engineering Project	Type of dam	Height (meters)	Engineering work volume (10,000 cubic meters)
Ta-huo-fang Reservoir	earth dam	48	780
Shih-san-ling Reservoir	" "	30	180
Ming-shan Reservoir	" "	32.5	90

The heights and engineering work volumes of large sized earth dams now under construction are given in the following table:

Engineering Project	Type of dam	Height (meters)	Engineering work volume (10,000 cubic meters)
Kang-nan Reservoir	earth dam	59	1,000
I-li Ho Hydro-Electric Power Station	" "	80.5	730
Sung-tao Reservoir	" "	78	450

Table continued--

Tan-chiang-k'ou Reservoir (two banks)	earth dam	75	800
Che-lin Reservoir	" "	66	550
Mi-yun Reservoir	" "	66	2,000
Chang-shu-kang Reservoir	" "	55	500
Wang-k'uai Reservoir	" "	48	600
Tung-feng Reservoir	" "	52	210
Ching-ho Reservoir	" "	38	700
Chao-ping Reservoir	" "	34	640

Under planning are the Ou chiang earth dam, 135 meters high with an engineering work volmue of 20 million cubic meters and the Sha-chien-tzu dam of mixed earth and stone, 120 meters high with an engineering work volume of 10 million cubic meters.

With the improvement of dam construction techniques, the method of dam building has also undergone reform. Since 1957, the method of pouring earth into the water has been used in the construction of many earth dams. Up to the present, 51 earth dams of a height of 15 meters and above, and 32 earth dams of a height of 25 meters and above have been constructed by this method.

Successful experiments have also been carried out in the use of the method of guided explosion in dam construction. The mixed earth and stone dam at Tung-ts'un-k'ou in Hopeh has been constructed with the use of this method.

Major earth dam projects using the method of pouring earth into the water (either completed or under construction) are given in the following table:

Engineering project	Type of dam	Height (meters)	Work volume (10,000 cubic meters)
Huang-pi-chuang Reservoir	earth dam	24	400
Fen Ho Reservoir	" "	60	450
Hsi-ying Reservoir	" "	44	300
Yueh-ch'eng Reservoir	" "	37	1,000
Kuan Ho Reservoir	" "	32.9	135

Dams constructed or planned with the use of the guided explosion method are given in the following table:

Engineering project	Type of dam	Height (meters)	Work volume (10,000 cubic meters)
Tung-s'un-k'ou Reservoir	mixed earth and stone	29	10
Shuang-chiang-k'ou Reservoir	mixed earth and stone	14	2.4
Ma-chin-tung Reservoir	mixed earth and stone	42	30

In 1957, in the construction of the large embankment of the Huai Ho at Shou Hsien, the method of dam construction with hydraulic power was carried out as an experiment. The results were very good and much data were acquired. In the construction of the Ta-lai earth dam in Heilungkiang and the Ta-shan earth dam in Kirin,

the hydraulic method will be used; and designing work is now being carried out. For the Chu Ho earth dam in Shansi, a combination of the hydraulic power and the pouring-earth-into-the water methods is being used. A previous experiment on this combined method has been successful.

During the past ten years, the designing and work techniques for earth dams in our country have been gradually improved through actual practice. Practical experience in technique has been summed up and raised to the level of scientific theory. The theory has in turn been used to guide practice. This is of great significance in the development of water conservation and hydro electric construction in our country.

We describe hereunder certain developments in our country in the designing of earth dams and in work techniques.

I. Selection of Construction Materials and Selection of Dam Sites

During the early stage of the founding of our state the earth dams constructed used mostly clay of even quality. Examples are the bases of the Pan-chiao earth dam and the Pai-sha earth dam. A dam with clay of even quality uses a single kind of earth material and has the advantage of simplicity in construction and management. But the resistance power of clay is lower and the stability of the slopes is inferior.

In some areas the clay has a high water content and its stickiness cannot be easily smashed. If rolling processes are not carried to the required degree of fineness or if the slopes are too steep--thus leading to the loss of the clay--fissures may result.inside the dam; or the top of the dam may shrink and fissures also result.

Moreover, work with clay is difficult in areas with greater rainfall. Accordingly, in the earth dams built in later stages the clay core wall was reduced in size as far as possible and the outer layers of the dam were

constructed with sand and gravel substances. Only when supplies of sand and gravel were lacking at the dam sites would clay of even quality be used.

In some dam sites where sand and gravel were lacking, but where conditions were permitted the use of stone materials, construction was carried out with mixed earth and stone, with the core wall constructed with clay of even quality and the outer layers constructed with pebbles. This technique has been adopted for many medium sized dams in Honan and Kwangtung. The method will be used in the recently planned Sha-chien-tzu dam.

Some areas have constructed dams with clay having a large gravel content (the gravel content reaching up to 80 percent). Such earth has been produced from silt accumulated on slopes and from floods; it does not lump and is easier to acquire and to use in construction. It is also less affected by rain; its resistance power is higher; and steeper slopes may therefore be constructed.

Such earth is used for construction in the earth dam of I-li Ho. The same earth has been used for the core wall, but pebbles larger than six millimeters must be removed so that the sticky components will be more than 15 percent. Also, the gravel content is restricted to less than 50 percent. These measures guarantee the core wall's resistance against leakage.

In recent construction of earth dams the clay sloping wall dam has been mostly adopted. The construction of the clay slope does not interfere with the construction of the gravel core of the dam. In the rainy season, construction of the gravel portion can be suspended and rush efforts made in the dry season.

In the case of the I-li Ho earth dam it was necessary to carry out the construction of the dam simultaneously with the conservation of water. If the sloping-wall type were adopted a long period would be needed for the piling of the dam foundations at the upper reaches of the river and water construction could not be carried out. The clay slope of the dam at the base of the dam must be very strong, and its construction cannot be quickly done. Water conservation would, therefore, be further affected.

Furthermore the alluvium at the base of the dam at the upper reaches was more than 50 percent lower than the alluvium at the base of the core wall, and much additional work on concrete piling would have been required. The core-wall type was therefore adopted.

At the base of the lower reaches of the slope, there was added a temporary slope of a very thin layer of clay over a distance of 40 meters. This enabled construction and water conservation to be undertaken simultaneously.

Earth dam construction techniques are developing in the direction of simplification of construction work; high speed, use of limited equipment, reduction of labor power to the minimum, and reduction of construction costs.

In the rolling type of dam [construction] a uniform kind of earth with gravel pebbles should be used as much as possible. Construction work using such material does not suffer much from the effects of rain and resistance power is strong. Large sized rolling machines (40 to 60 tons) should be used.

The rolling operation is shortened, progress is rapid, and the dryness of the earth can be increased to a very great extent. Thus the resistance power of the earth is raised and the dam slope may be as steep as possible, greatly reducing the work volume.

Pebbles which contain only small portion of sticky grains and dust may have smaller leakage coefficients after rolling by large machines and it may be possible to dispense with the use of an anti-leakage core wall or slope wall.

If the anti-leakage wall is needed, we may as far as possible adopt the narrow core wall or thin slope wall. In the use of the slope wall especially, this is desirable since construction work is subject to less interference.

At a dam site lacking pebble supplies we may adopt the mixed earth and stone dam with a core wall of a plastic type constructed with cobblestones. Such a dam can have a very steep slope and great economy can be effected.

Using local building supplies this type was adopted in recent years by various countries in the construction of dams of more than 100 meters high.

The method of guided explosion in dam construction has an extensive future. The use of "explosive energy" for the placing of stone materials into position replaces transportation. The use of "piling energy" replaces rolling operations. We are thus rid of heavy physical exertion. The proper study and improvement of explosion techniques and anti-leakage measures will promote a great development of the method of guided explosion in dam construction.

The hydraulic method of dam construction simplifies the transportation of supplies and eliminates the work of transportation over the top of the dam and rolling. The utilization of water power to separate the coarse and fine grains of earth for placement in the outer slopes and the core wall respectively provides a rational dam surface and at the same time relieves people of heavy physical exertion. This type of dam construction method has an extensive future on the rivers of the plains.

At present it cannot be universally popularized because we lack power dredgers and mud transmission steel pipes. But, the construction of dams with the use of semi-hydraulic power does not call for very elaborate equipment. It likewise eliminates transport and rolling operations on the top of the dam, and properly separates coarse and fine grains. This method is worth popularizing today.

Our country has an extensive area. We have innumerable medium and small water conservation and hydroelectric engineering projects. The dam construction method of pouring water into the earth is suited to medium and small engineering projects utilizing mass labor. Though it calls for an extensive labor force, it uses little equipment and is easily accepted by the masses. It is also a dam construction method capable of future development.

Water retention cisterns are still good anti-leakage structures for use at the bases of dams where alluvium is not very deep. If the alluvium is too deep, we may

use a water retention wall constructed of continuous concrete pillars or a concrete water retention wall which is rectangular in shape. The piling of a concrete screen is an even better method.

But our research efforts in the future should be directed toward the improvement of drilling and piling techniques so that the walls will not collapse, the number of steel pipes will be reduced, and speed will be accelerated.

The great Chinese Communist Party and the superior socialist system have bestowed perfect conditions on the people of the whole country for the full development of work activism and creativeness, and, at the same time, opened an extensive future for the water conservation and hydroelectric enterprises of our country. Through continous practice and the summing up of experiences, our dam construction techniques will be continually improved. In step with the leap forward of the whole national economy, water conservation and hydroelectric construction in our country will march toward the stage of new development.

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